TECHNICAL NOTE 355

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

Distributional Status of Falconiformes in Westcentral Arizona . . .

with Notes on Ecology, Reproductive Success, and Management

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August 1981

DISTRIBUTIONAL STATUS OF FALCONIFORMES IN WESTCENTRAL ARIZONA - WITH NOTES ON ECOLOGY, REPRODUCTIVE SUCCESS AND MANAGEMENT

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August 18, 1981

Cover - Lower left, adult zone-tailed hawk (Buteo albonotatus) at nest. Upper left, adult common black hawk (Buteogallus anthracinus anthracinus) soaring over nest grove. Lower right, immature female Cooper's Hawk (Accipiter cooperii). Lower right, immature female sharp-shinned hawk (Accipiter striatus velox). By Lauren M. Porzer

ABSTRACT

Winter and summer falconiform populations were studied on a 16,167 km^2 area in Mohave, Yavapai, Yuma and Maricopa Counties, Arizona between 15 January 1979 and 15 January 1981. Twenty-two falconiform species were observed on the study area; 13 species nested, 4 were present only in winter, 2 occurred only during migration and 3 were accidental. The American Kestrel (Falco sparverius), red-tailed hawk (Buteo jamacensis) and Cooper's Hawk (Accipiter cooperii) were the most common species in both seasons. Of 10 plant communities studied (montane conifer forest, pinyon-juniper woodland, interior chaparral, desert grassland, joshuatree-creosotebush desertscrub, paloverde-saguaro desertscrub, creosotebush-bursage desertscrub, mixed broadleaf riparian forest, cottonwood-willow riparian forest and mesquite-saltcedar woodland--see text for scientific names of plant species) highest winter falconiform abundances occurred in cottonwood-willow riparian forest, mixed broadleaf riparian forest and desert grassland communities. Highest abundances in summer were in cottonwood-willow and mixed broadleaf riparian forests and montane conifer forests. Winter falconiform species diversity was greatest in desert grassland, interior chaparral and creosotebush-bursage plant communities and summer falconiform diversity was greatest in montane conifer forest, cottonwood-willow forest and desert grassland.

Analysis of interspecific distributional relationships indicated vegetation structure and prey base strongly influenced falconiform occurrence and abundance. Falconiform habitat use overlap also varied with diet; species which prey heavily on birds tended to overlap little in distribution, species which prey on mammals exhibited no strong distributional relationships and species which prey on invertebrates overlapped strongly in distribution. Only 2 neotropical species, the black hawk (Buteogallus anthracinus) and the zone-tailed hawk (Buteo albonotatus) fed heavily on lower vertebrates, and these falconiformes hunted different habitat types.

Several land use activities including livestock grazing, mining and power line installation altered vegetation structural characteristics, prey populations or habitat quality sufficiently to affect changes in falconiform populations. Several management activities are recommended to mitigate negative impacts of these and other activities.

ACKNOWLEDGEMENTS

This study would not have been possible without the encouragement and assistance of the Phoenix District BLM staff, Don Seibert of the Arizona State Office BLM staff and personnel of the Arizona Game and Fish Department. In particular, Kent N. Woodruff and William J. Harrison, my research associates throughout 1980, contributed immensely to the project and are responsible for much of the data collected during that period. Robert S. Hall and Stephen Morris also participated as research associates for shorter periods. I thank K. Bruce Jones, William G. Kepner, Lauren M. Porzer and Rebecca L. Peck for sharing unpublished information on the distribution and ecology of various prey species and providing material for biomass estimations. Lauren Porzer also provided the cover illustration and assisted in the preparation of several figures used in the text. David T. Shaffer authored many of the computer packages used in data analysis. Mayo W. Call, William S. Clark, Richard L. Glinski, Teryl G. Grubb, William E. Luckett, Dr. Robert D. Ohmart and James R. Zook provided helpful comments and suggestions throughout the study. The Las Vegas District BLM Office provided valuable cooperation in the collection of raptor migration information. Karen Daniels and Elsie Russ typed the manuscript and provided valuable editorial assistance. The cooperation afforded by these agencies and individuals is greatly appreciated. My deepest debt of gratitude, however, goes to my wife Patricia for both permitting me to invest the time I needed to complete the project as well as assisting me when circumstances permitted.

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

INTRODUCTION

Environmental quality has become a major concern of the American public within the past decade. Out of this concern has emerged a growing desire to more carefully conserve and judiciously manage natural resources within the United States. Recognizing this trend, Congress has passed several acts which mandate federal land use agencies to consider and account for environmental impacts resulting from development of resources on public lands. The Bureau of Land Management (BLM), which administers public rangelands in the western United States, has been specifically directed to analyze the effects of land use projects on the environment and provide for the orderly use, development and preservation of land it administers by the National Environmental Policy Act of 1969 and the Federal Land Policy and Management Act of 1976. In order to comply with these directives, BLM's Phoenix District conducted resource inventories of the Hualapai, Aquarius, Harcuvar, Vulture and Skull Valley planning areas. Data collected during the inventory process will be incorporated into land use planning documents which govern the use, management and protection of the public rangelands in westcentral Arizona.

This report summarizes inventory data for the avian order Falconiformes (the vultures, kites, hawks, harrier, eagles, osprey and falcons). I have attempted to present information in a usable format by providing: (1) species accounts which summarize local distribution and cursory life history information for each species; (2) a population analysis which includes a cursory assessment of interspecific relationships and impacts of various land use activities on westcentral Arizona falconiform populations; and (3) management recommendations for priority species and habitats. In order to shorten the report, I have not included detailed general descriptions of ranges, food habits and ecology of each species. These kinds of information can be readily found in other texts (see for example Grossman and Hamlet 1964, Brown and Amadon 1968). Similarly, I have been conservative in citation of literature; the volume of works available on raptors is tremendous and I have relied heavily upon review and summary articles and texts. Although the data and findings presented will hopefully improve understanding and stimulate management for raptors in western Arizona, it should be realized that this represents a baseline effort. Many of the conclusions reached must be regarded as tentative until supported by additional work, and management recommendations are based upon short-term data and would undoubtedly benefit from additional study and modification.

STUDY AREA

Data were collected between 15 January 1979 and 15 January 1981 over a 16,167 km^2 study area situated in Mohave, Yavapai, Yuma and Maricopa Counties in westcentral Arizona (Fig. 1). Slightly over 8,410 km^2 (52 percent) of the area was administered by BLM with much of the remainder under state control. Most field work during 1979 and 1981 was in the northern half of the area. The southern half was studied in 1980.

Nearly all the study area was grazed by livestock; primarily cattle although sheep and horses were present on some allotments. Cotton, alfalfa and sorghum were grown on farmlands near Buckeye, Tonopah and Aguila (Fig. 2). Mining activity, primarily gold and copper, was prevalent in the Harcuvar, Vulture, Weaver, McCracken, Aquarius and Hualapai Mountains as well as on upper portions of the Hassayampa River and Burro Creek.

Physiography of the study area is diverse. Fenneman (1931) placed westcentral Arizona in the Basin and Range Province of North America. The study area encompasses portions of the Sonoran Desert and Mexican Highland subdivisions of this province. The Weaver Mountains and Aquarius Cliffs represent divisions between these regions with the Mexican Highland subdivision to the east and Sonoran Desert subdivision to the west. Mexican Highlands primarily consist of deeply dissected plateaus and mesas irregularly interrupted by low-prominence amorphous peaks. The Sonoran Desert section exhibits a range-valley aspect with prominent mountain ranges sloping abruptly into broad valleys. Elevations on the study area range from 2,507 m at Hualapai Peak 19 km south of Kingman to 230 m at the Bill Williams River on the western study area boundary.

Northern portions of the study area are drained by tributaries of the Bill Williams River. Major drainages include Kirkland Creek, Sycamore Creek, Santa Maria River, Big Sandy River, Burro Creek, Francis Creek, Conger Creek and Pine Creek. Southern parts are drained by tributaries of the Gila River, including the Hassayampa River and Centennial Wash. Perennial surface waters were present in all aforementioned drainages, primarily in upper reaches (see Kepner 1979 and 1981).

Climatic conditions vary with elevation and aspect. Maximum diurnal temperatures typically peak in July, with highs averaging 31° C in low valleys and 26° C in mesas and mountains. Winter diurnal highs average lowest in December or January. Highs in winter average 8.2° C in valleys and 5.6° C in mesas and mountains. In mountains above 1,700 m elevation winter temperatures frequently remain below 0° C for extended periods. Precipitation exhibits a bimodal pattern with peak amounts appearing in July or August and December separated by periods of spring and autumn drought. Winter precipitation is associated with large-scale cyclonic systems which originate over the Pacific Ocean. In summer convective storms, resulting from moist southeasterly airflow over heated land surfaces, are responsible for most precipitation. While summer precipitation amounts are generally greater than winter, extent of thunderstorm activity is greatest in southern and eastern parts of the area. Annual precipitation amounts average 18.9 cm in western deserts, 25.4 cm in central deserts and 44 cm in mesas and mountains. Winter precipitation often occurs as snow above 1,700 m elevation (climatic data from Sellers and Hill 1974). During the study period winter precipitation averaged greater than normal in both years while summer precipitation was below normal in 1979 and 1980. High winter precipitation resulted in vigorous annual grass and forb production in both years. In southwestern North America abundance of winter annual vegetation is typically accompanied by population increases among many mammalian falconiform prey species (see Fitch 1947, Sheffler 1958, Turkowski 1975).

Vegetation of the study area was complex, and plant communities indicative of Rocky Mountain, Mogollon, Great Basin, Mohavian and Sonoran biogeographic provinces were well represented. For the purposes of this investigation, 10 major plant communities were recognized. Characteristics of each, following the classification system of Brown et al. (1979a), follow. Representative photographs of each plant community are included in Appendix II.

Montane Conifer Forest Plant Community

True conifer forests were restricted to about 49 km^2 at elevations above 1,700 m in the Hualapai Mountains (Fig. 3). Elements of the Rocky Mountain Montane Conifer Forest Biome were well represented. Ponderosa pine (Pinus ponderosa)-Gambel Oak (Quercus gambelii) associations dominated the community, however, in mesic situations above 1,900 m loose associations of Douglas Fir (Pseudotsuga menziesi), white fir (Abies concolor) and aspen (Populus tremuloides) were interspersed with pines and oaks. Between 1,700 m and 1,900 m conifer forests were generally restricted to north and east facing slopes. Within this elevation range stands were typically open and comprised of mature to senescent pines and oaks. Shrub live oak (Quercus turbinella) and pringle manzanita (Arctostaphylos pringlei) formed dense shrub understories in these stands. Above 1,900 m stands were more contiguous and were comprised of a diverse size range of trees. In closed stands little understory was present. Large rock outcrops, burns vegetated with dense, shrub-like stands of Gambel Oak, aspen and shrub live oak and man-made clearings provided a mosaic of structural and seral conditions throughout this community.

Pinyon-juniper Woodland Plant Community

Pinyon (Pinus monophyla and P. edulis)-juniper (Juniperus monosperma and J. osteosperma) woodlands occupied 1,164 km^2, primarily in montane terrain in the Hualapai and Weaver Mountains above 1,280 m (Fig. 3). Arboreal elements were typical of the Great Basin Conifer Woodland Biome, but understory was generally of interior (Mogollon) chaparral affinity (shrub live oak and manzanita). Throughout this community forest structure and composition varied; from open, scattered juniper studded savannas to dense contiguous woodlands dominated by pinyon. Density of shrub and other understory components varied inversely with arboreal canopy cover. Exclusive juniper woodlands were present on many historic grassland formations, particularly near Bagdad. Similar juniper invasions have been described throughout the Great Basin region (Arnold et al. 1964). Because the natural history of pure juniper stands on the study area was uncertain, I restricted intensive study of falconiform populations to well developed mixed tree woodlands.

Interior Chaparral Plant Community

Interior (Mogollon) chaparral, primarily comprised of shrub live oak, pringle manzanita, skunk bush (Rhus trilobata), buckbush (Ceanothus spp.) and sugar sumac (Rhus ovata), occurred over 2,650 km^2 of the study area on exposed, warm slopes at elevations from 1,900 m to 1,100 m (Fig. 3). Shrub density varied greatly, with nearly complete closure on granitic soils where

precipitation averaged over 35 cm annually. Many Arizona shrub oak associations represent fire disclimax communities (Carmichael et al. 1978). Although extensive tracts of homogeneous chaparral were present on the study area, in the Weaver, Aquarius and Hualapai mountains chaparral typically occurred in patchy association with pinyon-juniper woodland and/or montane conifer forest.

Desert Grassland Plant Community

Grassland formations on the study area were biogeographically complex; 3 associations were noted. The most extensive was on mesas of the Mexican Highlands at elevations around 1,200 m; primarily a tobosa (*Hilaria mutica*)-mixed scrub association (Fig. 3). Mesa grasslands were generally rolling expanses of short grasses broken by occasional drainages vegetated with shrub live oak and net-leaf hackberry (*Celtis reticulata*). Thickets of catclaw (*Acacia greggii*) were also common. A relict mixed grass-palmilla (*Yucca elata*) association persisted between Congress and Aguila at an elevation of about 650 m. Much of this grassland exhibited extensive evidence of livestock overuse; soils were deeply eroded and mesquite (*Prosopis* spp.) thickets were numerous (see Humphrey 1958). Around the Hualapai Mountains a Great Plains gramma (*Bouteloua* spp.)-mixed grass association occurred in an open pinyon-juniper savannah. Snakeweed (*Gutierrezia* spp.) and annual grasses dominated understory in this area during the study period. Intensive study of falconiform populations was restricted to mesa grasslands, however, disclimax associations in other grassland formations were qualitatively examined for comparison. Grasslands covered about 1,060 km^2 of the study area.

Joshuatree-creosotebush Plant Community

Warm-temperate Mohave desertscrub flora prevailed on about 1,566 km^2 in moderate elevation valleys (1100 m to 600 m elevation) in western portions of the study area (Fig. 3). Joshuatree (*Yucca brevifolia*)- creosotebush (*Larrea tridentata*) associations were well developed throughout. Community aspect varied from expansive creosotebush flatlands with scattered joshuatrees to relatively dense, contiguous stands of joshuatree with creosotebush shrub understory. Grass and forb cover was generally sparse. Ephemeral washes vegetated with foothill paloverde (*Cercidium microphyllum*), blue paloverde (*C. floridum*) and occasionally saguaro (*Cereus giganteus*) were numerous. Saguaro and foothill paloverde were also present on hillsides and small rises in otherwise pure joshuatree-creosotebush formations.

Paloverde-saguaro (Arizona Upland) Plant Community

Subtropical Sonoran desertscrub associations of foothill paloverde and saguaro were present on 5,680 km^2 on hillsides, bajadas and some valleys between 600 m and 400 m elevation (Fig. 3). In eastern parts of the study area paloverde and saguaro formed dense, structurally diverse stands; however, in western and southern parts stands were typically open, and comprised of only scattered paloverde and saguaro with an understory of creosotebush and white bursage (*Ambrosia dumosa*). Exceptions occurred along northern and eastern bajadas of the Harcuvar and Harquahala Mountains where paloverde-saguaro formations were atypically diverse and vigorous. Ephemeral

washes also supported dense paloverde-saguaro associations in many areas, along with blue paloverde and ironwood (Olneya tesota).

Creosotebush-bursage (Lower Colorado) Plant Community

In low valleys (below 500 m elevation) of western and southern parts of the study area subtropical Sonoran desertscrub creosotebush-white bursage associations dominated (Fig. 3). This community typically occupied the center of valleys, flanked on bajadas by paloverde-saguaro associations of varying structural diversity. As with other desertscrub formations, understory was depauperate on other than deep soils in washes where hummocks of big galetta (Hilaria rigida) were occasional. Arizona upland elements, including saguaro, blue and foothill paloverde and ironwood persisted as arborescent stringers well into the creosotebush-bursage community along ephemeral washes. This community occupied about 3,830 km^2 of the study area.

Mixed Broadleaf Riparian Forest Plant Community

As a whole, riparian communities on the study area were difficult to classify because of the diversity of floral constituents and intergradation between community types. Interior (Mogollon) Southwestern Riparian Deciduous Forest Biome elements occupied about 11 km^2 on floodplains at elevations above 975 m. Several forest types were present, including (in order of dominance by decreasing elevation) Gambel oak-walnut (Juglans major) associations, walnut-alder (Alnus oblongifolia) associations, walnut-ash (Fraxinus pennsylvanicus) associations and sycamore (Platanus wrightii)-mixed broadleaf associations. Mixed broadleaf communities were present on both perennial and ephemeral drainages where surface flow occurred between November and March (Hibbert et al. 1974). Forest galleries varied from scattered clumps of trees to dense, contiguous corridor forests. In corridor forests canopy cover, foliage density and vertical evenness of foliage distribution were greater than in any other plant community, with the exception of mesquite-saltcedar. Net-leaf hackberry and catclaw bosques frequently occurred on upper floodplain terraces. In and immediately southeast of the Weaver Mountains Madrean evergreen associations of Emory Oak (Quercus emoryi) occupied upper floodplain terraces in the mixed broadleaf community. The most prevalent upland type associated with mixed broadleaf riparian forest was interior chaparral, however, montane conifer forest, pinyon-juniper woodland and rarely desert grassland communities were proximate. Quantitative falconiform studies were conducted in mixed broadleaf forest adjacent to interior chaparral.

Cottonwood-willow Riparian Forest

Sonoran riparian cottonwood (Populus fremontii)-willow (Salix spp.) associations were best represented below 850 m elevation along perennial and ephemeral drainages with surface flow from November to March (Hibbert et al. 1974). Mixed broadleaf associations occurred interspersed with cottonwood and willow between 975 m and 650 m. About 32 km^2 of cottonwood-willow forest were present on the study area. Cottonwood-willow stands varied tremendously in canopy configuration and tree size, presumably dependent upon hydrologic conditions and intensity of livestock use. Under favorable

conditions with little cattle and burro grazing, stands were comprised of a diversity of tree size classes and were frequently full canopy galleries. In heavily grazed areas lone trees or scattered stands of mature or senescent trees with comparatively little canopy predominated (Fig. 4). Understory of burro bush (Hymenoclea monogyra), cheesebush (H. salsola) and seepwillow (Baccharis salicifolia) was prevalent in open stands. Upper floodplains were occupied by mesquite-graythorn (Zizyphus obtusifolia)-catclaw bosques in most areas. Adjacent uplands were primarily paloverde-saguaro desertscrub although chaparral, desert grassland and rarely joshuatree-creosotebush and creosotebush-bursage communities were proximate. Quantitative falconiform studies were conducted in cottonwood-willow forests adjacent to chaparral, desert grassland and paloverde-saguaro formations.

Mesquite-saltcedar Woodland Plant Community

Sonoran riparian mesquite-saltcedar (Tamarix chinensis) associ ions occurred below 800 m elevation primarily along ephemeral and intermittent drainages where winter surface flows were irregular. This woodland type occurred on about 97 km^2. Saltcedar was an invading species in most riparian corridors on the study area (see Horton 1960, Horton et al. 1960, Turner 1974, Warren and Turner 1975), and typically formed dense, almost impenetrable thickets with mesquite in the elevational range noted above. Stands of athel (Tamarix aphyla) were frequently associated with mesquite and saltcedar. This community was best developed on the Big Sandy, Santa Maria and Bill Williams Rivers and Centennial Wash where extensive, continuous woodlands several km^2 in size were common. Open stands of mesquite and saltcedar were also present in these situations, especially around the perimeter of dense woodlands. Understory in open woodlands included numerous annual grasses and saltbush (Atriplex polycarpa). Little understory vegetation occurred in dense stands. Mesquite-saltcedar woodlands were also well developed around man-made stock ponds in uplands. Canopy configuration around artificial ponds closely resembled that along riverine systems. In rare cases pure mesquite woodlands were observed, both along drainages and around ponds. Upland communities from desert grassland to creosotebush-bursage occurred adjacent to mesquite-saltcedar woodland. Stands in association with all upland communities were studied.

METHODS AND DATA TREATMENT

Data Collection

Falconiform Populations

Information on falconiform distributions, seasonal occurrence and relative abundance were obtained in each plant community. Initially, all falconiform sightings were recorded with reference to date, location, vegetation at locality, age and sex of individual and activity. In 1980 and 1981 only sightings of unusual species were so noted.

Distributional records were supplemented by sample area and vehicle count studies. Two 7.8 km^2 sample areas were established in relatively homogeneous tracts of pinyon-juniper woodland, interior chaparral, desert

grassland, joshuatree-creosotebush, paloverde-saguaro, and creosotebush-bursage plant communities. Three 2.59 km^2 sample areas were established in montane conifer forest, mixed broadleaf riparian forest, cottonwood-willow riparian forest and mesquite-saltcedar woodland communities. To avoid bias, sample areas were placed where livestock use was moderate. As a consequence sample areas could not be randomly selected, however, delineations were made with no influential field knowledge of any site. All sample areas but montane conifer forest were intensively surveyed in winter (November-February) and in summer (March-July) to estimate the number and species of falconiformes utilizing each area. The montane conifer area was not studied in winter due to inaccessibility. Raptors observed on areas were identified, captured and banded when possible and age and sex were determined when feasible. Peculiarities in plumage were noted for each individual observed and location of each bird sighted was plotted on field maps drawn for each sample area. Roost sites, prey plucking perches, hunting perches and nest sites were similarly recorded. Dense vegetation was carefully searched for signs of use (e.g. urates, pellets and moulted feathers). Falconiform feathers located were identified to species, age and sex when possible. Four 48.4 km vehicle count routes were established and driven 28 times between 15 September, 1979 and 15 May, 1980. Counts were conducted weekly between 15 September and 10 November and twice monthly thereafter. Routes were carefully selected so all major plant communities (with the exception of mixed broadleaf riparian forest and montane conifer forest) were well represented within the total sampled area. Roads utilized were primarily unimproved and received little traffic. Power distribution lines and other unnatural structures attractive to perching raptors were avoided; some segments of count areas were later deleted from analysis because proximity to power lines may have biased counts. Counts were initiated one-half hour after sunrise and averaged 3 hours to completion (vehicle speed ranged from 15 to 30 km/hr). All raptors sighted within 150 m lateral to roads were counted. Each raptor thus encountered was identified, aged and sexed when possible, and perch or flight type and height were noted. Activity of each individual was subjectively determined based upon observed behavior (primary activity classes included maintenance, hunting, inter- or intraspecific conflict, feeding, resting and courtship or nesting). I also recorded perpendicular distance of the individual from the vehicle and linear distance from the starting point. Vegetation along each census route was categorized by linear and lateral distance so each observation could be associated with a plant community type. At the start, finish, and at hourly intervals between meterological conditions, including temperature, percent cloud cover, cloud type, cloud height, wind velocity (Beaufort scale) and presence or absence of precipitation were noted.

A second phase of this part of the inventory involved identifying nesting habitats and reproductive performance. In mid-January intensive searches for nesting sites were initiated. Primary emphasis was upon more easily observed platform nesting species due to time limitations. In addition to nest searches on sample areas: 1) selected cliffs and riparian broadleaf forests were flown by helicopter (Bell 206B) and previously occupied raptor nesting sites were identified and recorded; and 2) large sections of uninterrupted upland in all plant communities were surveyed on foot and by vehicle to locate old nest sites and territorial pairs of adult

falconiformes. All sites where evidence of initial nesting activity were observed were recorded. Sites thus delineated were revisited to determine if nesting was attempted and to ascertain clutch size at active nests. Eggs were viewed with a 15 m mirror pole or from adjacent trees or high terrain. No nests were climbed at this time although some inaccessible sites were quickly viewed from a helicopter. Nests were again visited when young were present to ascertain brood size. Nestlings were banded and age of young was estimated in many nests. An attempt was made to determine fledging success although logistic constraints prevented returning to a large number of sites. I have therefore considered young surviving 75 percent of the nestling period successfully fledged. Mortality was low during later portions of the nestling period at nests studied, however, for some species significant losses may occur in this and post-fledgling periods (Snyder and Wiley 1976). Caution should be exercised in comparing my fledging statistics with data from other studies.

Falconiform Diets

Pellets and prey remains were collected periodically from raptor plucking perches and nest sites. Each sample was individually packaged and labeled. Observations of prey captures and feeding falconiformes were also noted when identification of prey was possible. Stomachs and crops of individuals found dead were examined as time permitted. Observational blinds were erected at 2 common black hawk (B. a. anthracinus) nest sites on Burro Creek to obtain diet information for this species (Millsap and Harrison 1981). One Cooper's Hawk (Accipiter cooperii) and 2 zone-tailed hawk (Buteo albonotatus) nests were also occasionally observed from blinds.

Important Habitat Features

Features of vegetation structure were measured at randomly selected hunting perches of some falconiformes and at arboreal nest sites. At each measured site four 30.5 m transects were established at right angles radiating outward from the perch or nest substrate. Vertical distribution of low height vegetation was measured at 10 equidistant points (3.1 m apart) on each transect. This was accomplished by passing a suspended line through vegetation over each point and recording the number of 0.6 m line increments contacting vegetation and their locations. Vertical distribution of overstory vegetation was determined by passing a 15 m pole over each point and recording vegetation contacts by 0.6 m height increment or by visually estimating contacts and determining heights with a hypsometer. Life-form (Arnold 1955) of vegetation was recorded for each contact; if more than 1 life-form was present all were recorded. At nest sites tree density and distribution were determined by counting all trees within 3 m of transect lines. Only trees greater than 1.4 m in height were considered. Diameter at breast height (DBH) and maximum height of each tree sampled, including nest trees, were determined.

Little time was spent measuring features of cliff nesting sites since many were only viewed from aircraft. Cliff aspect and nest exposure were cursorily noted during initial visits. In difficult cases cliff aspect was later determined from map and aerial photo analysis. Cliff and nest height

were also noted initially and later revised with the aid of maps and photographs. Estimates of cliff surface area were calculated from topographic map analysis and field estimates of cliff length and height at midpoint and at outer margins.

Percent slope, distance to and type of surface water, distance from and type of nearest human disturbance and plant community type were also determined at nest sites. Percent slope was measured only at tree nests. The difference in elevation between opposing transect end-points was used to calculate slope. Distance to nearest water and disturbance were estimated from analysis of maps, aerial photographs and on-site investigations. Nests were assigned to a plant community or ecotone type based upon proximate vegetation; however, all plant community types within 1.6 km of each nest were noted.

Data Treatment

Relative abundance estimates were calculated from census route and sample area data. Minimal estimates of population size were calculated for each species on each sample area during winter and summer, and estimates from sample areas in the same plant community were averaged for each season. Census route data were modified to account for possible biases in actual counts for some species before analysis. Many studies have shown detectability differs between species and habitats in line transect population analyses (Emlen 1971 and 1977, Burnham et _al_. 1980). Usually detection differences are measured by comparing numbers of sightings at distances close to the observer with those at progressively greater lateral distances; species which are difficult to detect are less apt to be observed at greater distances. It was initially assumed all falconiformes within the 150 m strip on either side of census routes could be observed and counted. Chi-square tests were employed to test this hypothesis assuming there would be no significant difference in the number of individuals of any species seen at lateral distances of 0-50 m, 51-100 m and 101-150 m. The null hypothesis was rejected for the sharp-shinned hawk (_Accipiter striatus_) and Cooper's Hawk (_Accipiter cooperii_) in chaparral, pinyon-juniper and cottonwood-willow plant communities ($p < 0.05$). To compensate for detection bias width of the count corridor was reduced by one-half (to 75 m) on each side of the road for Cooper's Hawks and three-fourths (to 38 m) for sharp-shinned hawks in these plant communities. Using only sightings within these reduced corridors the distribution of observations did not differ significantly from uniform for either species (X^2 test, $p > 0.98$ for Cooper's Hawk and $p > 0.75$ for sharp-shinned hawk). Incorporating these adjustments, the number of km^2 of each plant community actually surveyed per count for each species was determined. Average number of individuals of each species observed in each plant community per count day was then calculated. Both census route and sample area average population estimates were converted to number of individuals of each species per km^2 of each plant community surveyed, and census route and sample area abundance estimates were averaged together for each plant community for winter and summer. Relative abundance estimates were calculated in 2 ways: (1) intraspecific relative abundance which provided comparative information between plant communities for each species; and (2) interspecific relative abundance which provided comparative

information between species for each plant community. Intraspecific relative abundance was calculated using the formula:

$$Ni/Nj,$$

where Ni = abundance estimate for species j in the ith plant community and Nj = the sum of abundance estimates for species j in all plant communities. Interspecific relative abundance was calculated using the formula:

$$Nij/N,$$

where Nij = abundance estimate for the jth species in the ith plant community and N = the sum of abundance estimates for all species in the ith plant community.

Reproductive statistics were calculated as mean values ± 1 standard deviation (S.D.) unless otherwise noted. Means were derived using data from all known occupied territories for each species whether eggs were laid or not. Inasmuch as many pairs failed to lay eggs this method provided a more rigorous description of actual reproductive performance of the population. Breeding statistics were also reworked for comparison with compatible information in the literature. Probabilities of egg and chick survivorship were calculated using the Mayfield 40-percent method (Johnson 1979). Dates of egg deposition, hatching and fledging are expressed as extremes and medians (50 percent) for each species. Dates were determined from actual observations and projections at nests where approximate ages of young were known.

Prey observations were aggregated for each pertinent falconiform and frequency of occurrence of each prey species (or lowest identified taxonomic level) and major taxa or trophic level (e.g. mammals, birds, lower vertebrates and invertebrates) in diet was computed. Biomass contribution of each prey species (or major taxa) was also calculated. Weight of each prey item was estimated by matching it with a similar sized individual of that species of known weight. For most prey species under 200 g (adult weight) a standard mean weight was applied. Materials used for weight determinations were live-caught or freshly killed specimens from the study area when possible, however, local museum material were utilized in some cases. Average weights and scientific names of prey species are summarized in Appendix I. Pellet samples were analyzed using methods described by Craighead and Craighead (1956) and Marti (1974). Pellet and prey remain studies of falconiform diets provide biased results since many foods, particularly soft bodied invertebrate and amphibian prey, irregularly appear in pellets or under plucking perches (see Snyder and Wiley 1976 for discussion). This inherent bias limits the usefulness of data presented; however, the information serves to delineate some important prey species as well as a broad picture of the prey niche of several falconiformes. Dietary data presented in this paper should not be considered quantitative unless otherwise noted.

Vegetation data were utilized to describe vegetation characteristics of perch and nest sites. Several characters were examined. At perch sites canopy area was the number of 0.6 m vertical increments contacted by

vegetation divided by the total number of increments where contacts were possible (proportion of area occupied by foliage). Canopy width was the maximum height of vegetation. Canopy volume index was canopy area multiplied by canopy width (compressed width of foliage). Emphasis at raptor nest sites was upon describing configuration of the arborescent canopy. Canopy area was the number of vertical height increments contacting arborescent foliage divided by the number where contact was possible. Canopy width was the distance between the minimum and maximum increments where arboresent foliage was contacted at each site. Tree density was determined by counting the number of trees within the 792 m^2 area sampled at each site. Values were converted to number of trees per hectare (ha) for convenience. Tree size was expressed as a volume (m^3) index reflecting both DBH and height. Tree size was calculated using the formula:

$$V = (0.7854 \ DBH^2) \ (H),$$

where DBH = diameter at breast height in m, H = tree height in m and V = volume (size) index. Percent slope was the greatest change in elevation (in feet) between end points of opposing transects at each nest divided by 200. A single value was calculated for each parameter at each nest or perch site. Perch site data were grouped by species regardless of plant community for calculation of means; nest data were grouped by species and further subdivided by plant community. Dispersion values are 1 S. D. unless otherwise noted. Sample size in tables refers to the number of perch or nest sites measured.

All statistical analyses were performed on the BLM Honeywell 6680 computer timesharing system. Diversity indices were calculated using the Shannon and Weaver (1949) formula. Overlap indices were calculated using the formula given by Horn (1966). Relations between 2 sets of variables were tested using product-moment correlation coefficients and comparisons of mean values or data sets were conducted using the t' test (Sokal and Rohlf 1969). Tests of value distributions were made using Chi-square tests employing Yates corrections for continuity when V = 1 (Yates 1934).

DISTRIBUTION AND ECOLOGY

Twenty-two species of falconiformes were observed on the study area. Breeding was verified for 13 species, 4 species were present only during winter, 2 species occurred only on migration and 3 were considered accidental or vagrant. Two additional species of falconiformes have been reported from the study area, the red-shouldered hawk (*Buteo lineatus*) (Witzeman et *al*. 1978) and the black vulture (*Coragyps atratus*) (Phillips et *al*. 1964), although none were detected during the study period.

The following section briefly details taxonomy, distribution and status, food habits (when known) and reproductive success for each species on the study area. Data for regularly encountered and widely distributed species have been quantitatively summarized in Tables 1 - 8. Because quantitative data were collected through intensive study of small areas they provided only

limited information on distributions of uncommon and patchily distributed species. Qualitative assessments are presented for these species. Unless otherwise noted, observations were by the author or research associates.

Turkey Vulture

Taxonomy

No turkey vultures were examined from the study area. Cathartes aura aura is the only subspecies likely to occur in Arizona (Brown and Amadon 1968).

Distribution and Status

Common during spring, summer and autumn; largely absent in winter. Latest autumn record 2 November, earliest spring record 8 February. One January record in 1981. Widespread in all plant communities. Roosting concentrations of up to 95 individuals were observed in cottonwood stands near Yava along Kirkland Creek, in ponderosa pine in the Hualapai Mountains and in mesquite near Wikieup on the Big Sandy River. Nesting was observed in caves in cliffs above Alamo Lake and suspected in boulder-strewn hillsides in Sacramento Valley, Hualapai Mountains, Weaver Mountains, near Hillside and near Bagdad. The turkey vulture was probably a widespread breeding species. Turkey vultures were commonly observed over major highways during feeding forays, presumably searching for road-killed animals. Quantitative assessment of abundance and distribution was not performed.

Food Habits

No quantitative diet data were collected for the turkey vulture. Commonly this species was observed feeding on road-killed lagamorphs, sciurids and reptiles. Occasionally individuals were seen feeding on carcasses of large ungulates, particularly still-born calves. Diet is primarily carrion (Brown and Amadon 1968).

Breeding and Productivity

Four cave nests were observed on 12 June 1979. One contained 2 young about 20 days old, 2 contained 1 young about 20 days old and the fourth contained 1 apparently addled egg.

White-tailed Kite

Taxonomy

No specimens are available from Arizona. Undoubtedly Elanus leucurus majusculus is the subspecies present. This is a well established breeding race in coastal southern California and northwestern Baja California and Arizona records are probably emigrants from this population (Ellis and Monson 1979).

Distribution and Status

Inclusion of this species is based upon a single sight record on 22 October, 1979 (S. Morris and A. Morris, written description). The observed individual was an adult in flight over a complex of agricultural land, mesquite-saltcedar woodland and desert grassland. Ellis and Monson (1979) described 1 documented and 3 undocumented white-tailed kite records for Arizona; all of adults and all in late summer, autumn or winter. At present this species appears to be accidental in western parts of the state.

Mississippi Kite

Taxonomy

The Mississippi Kite, _Ictinia_ _misisippiensis_, is monotypic.

Distribution and Status

Rare and irregular summer and autumn vagrant in riparian forests of western Arizona. One observation during the study period, an extremely late immature on 26 October 1979 in mesquite-saltcedar woodland with scattered cottonwoods near Salome. R. Hanna and S. Hecker (_fide_ R. Glinski) observed 1 adult and 1 second-year Mississippi Kite on the Big Sandy River near Wikieup in August 1979, and A. Moorhouse (_fide_ R. Glinski) reported a single individual on the Hassayampa River below Wickenburg in July 1979. Breeding has not been observed on the study area, although the species has recently become an established nester in eastern Arizona (Monson 1972) and may continue to expand its range into cottonwood forests elsewhere in the state. The closest regularly active nesting colony is on the Gila River near Kearny (R. Glinski, pers. comm.).

Food Habits

No specific data are available. On the San Pedro River cicadas (_Diceroprocta apache_) are important prey (R. Glinski, pers. comm.).

Goshawk

Taxonomy

Two subspecies of goshawk occur in Arizona; the northern goshawk, _Accipiter_ _gentilis_ _atricipillus_ and Apache goshawk, _A_. _g_. _apache_. The latter subspecies is taxonomically marginal and restricted to montane conifer forests of southeastern Arizona and northern Mexico (Wattel 1973). Two migrants trapped in southern Nevada during autumn 1980 measured well within the range of _A_. _g_. _atricipillus_ (Millsap and Zook, unpubl. data), and this race has been widely reported throughout the northern portions of Arizona (Phillips et _al_. 1964). It seems reasonable to conclude _A_. _g_. _atricipillus_ is the dominant and probably the only goshawk in western Arizona.

Distribution and Status

Rare but widespread wintering species and uncommon nester in montane conifer forest. Ten goshawks were observed in winter; 5 in chaparral (all on sample areas, see Table 1), 2 in pinyon-juniper woodland and 3 in

mesquite-saltcedar woodland. Phillips et al. (1964) described the goshawk as rare in winter in lowlands of the western part of Arizona. Recent records support this conclusion but suggest lowland occurrence is regular. Some recent lowland records include 1 at Topock Marsh on the Colorado River, November 1972; 1 in Phoenix, December 1973 - February 1974 (both Parker 1974); 5 across southwestern Arizona in winter of 1975 (Witzeman et al. 1975) and another in Phoenix in 1976 (Heilbrun 1977). My 3 lowland records were all of immatures in mesquite-saltcedar woodlands. Together with other records these observations suggest mesquite riparian woodlands (and other mesquite associations) may be the favored wintering habitat of lowland immatures. In contrast, my winter sightings in Upper Sonoran Life-zone plant communities were all of adult goshawks. While adults probably occur in lowlands during winter it is possible higher elevations are preferred.

Goshawks nested in montane conifer forest in the Hualapai Mountains and perhaps (based upon a single observation of an adult in late May 1980) in pinyon-juniper woodland in the Weaver Mountains. The species was observed regularly on montane conifer forest plots in summer (Table 3). Two nests were observed in mature, dense stands of large ponderosa pine on hillside terraces. Surface water was present within 500 m of 1 nest; no water was present within 1 km of the second. Defended territories were also found in aspen and Douglas Fir stands (a total of 4 breeding territories found, all in the Hualapai Mountains).

Food Habits

Four prey items were observed at 1 active nest in the Hualapai Mountains; 1 Abert's Squirrel (Sciurus aberti), 2 cottontail rabbits (Sylvilagus spp.) and 1 rock squirrel (Spermophilus variegatus). Diet is probably variable. In southeastern Arizona Snyder and Wiley (1976) found only birds in the diet of 1 pair; squirrels, rabbits and medium-sized birds are typical prey (see Sherrod 1979). Local variations in prey vulnerability and preferences of individual hawks probably play a determining role in goshawk predation.

Breeding and Productivity

One nest climbed in the Hualapai Mountains contained 3 young about 5 days old on 15 June 1979. Estimated laying date was 12 May and young probably fledged in mid- or late July. Data were not collected on other territories located.

Sharp-shinned Hawk

Taxonomy

Measurements and plumages of sharp-shinned hawk specimens collected in Mohave County, Arizona (University of Arizona collection) fall within the range of Accipiter striatus velox (Wattel 1973), as do plumages and measurements of 63 migrants banded in southern Nevada during autumn 1981 (Millsap and Zook, unpub. data). A. s. suttoni, characterized by unbarred rufous thighs and large size (compared to A. s. velox), has been reported

from the San Luis and Ajo Mountains of northwestern Chihuahua and northern Sonora (Phillips et al. 1964, Wattel 1973). This race apparently does not occur in western Arizona although it may be present in the Huachuca Mountains (Snyder and Glinski 1978).

Distribution and Status

Uncommon but widespread in winter; a rare breeder in montane conifer forest in the Hualapai Mountains. Sharp-shinned hawks were observed in 6 plant communities during winter (Table 1). Winter distributional diversity and equitability were comparatively low (Table 2), reflecting the large proportion of observations from mesquite-saltcedar woodland and mixed broadleaf riparian forest communities. Vegetation measurements at perch sites revealed a strong tendency for sharp-shinned hawks to utilize areas with substantial arboreal cover (Table 9). In desertscrub communities sharp-shinned hawks were seldom observed far from dense paloverde and ironwood stringers along ephemeral streams and mesquite stands around stock ponds. Presumably, the winter sharp-shinned hawk population consisted primarily of northern migrants. Millsap and Zook (1981) studied migration of this species in southern Nevada in 1980 and reported relatively strong movements between the second week of September and second week of October.

During summer sharp-shinned hawks exhibited one of the most restricted distributions (Tables 3 and 4). Only 1 active breeding territory was located. The nest was situated in a dense stand of relatively young ponderosa pine on a hillside terrace. The site had burned 20 years previous and was within 500 m of flowing water. An immature female was also seen on Sycamore Creek near Yava in June 1980 but no nest was found.

Food Habits

No data are available from the study area. Sharp-shinned hawks specialize on avian prey, and Snyder and Wiley (1976) reported 93 percent of the diet as small birds based upon food habit studies across North America.

Breeding and Productivity

The single nest located contained 4 recently hatched young on 30 June 1979. Estimated laying date was 28 May and young probably fledged in mid-July.

Cooper's Hawk

Taxonomy

The Cooper's Hawk, Accipiter cooperii, is monotypic. Friedman (1950) and others considered the eastern (A. c. cooperii) and western (A. c. mexicanus) populations to be sub-specifically distinct, however, this designation has since been dismissed.

Distribution and Status

Common wintering and breeding species in forest and woodland plant communities. Cooper's Hawks were observed in all plant communities in winter and 7 in summer (Tables 1 and 3). Adult males and immatures were uncommon in winter in Transition and Upper Sonoran Life-zones, but dominated winter lowland populations. Adult females appeared sedentary; 6 banded in Upper Sonoran vegetation in winter subsequently nested nearby. These observations suggest the species is partially migratory (at least at higher elevations) in western Arizona.

Distributional diversity was comparatively high both in winter and summer (Tables 2 and 4), although evenness was relatively low. Low evenness values reflected disproportionately high abundance in riparian forests and woodlands. As with sharp-shinned hawks, Cooper's Hawks selected perches in areas with high vegetation and were seldom observed away from wooded washes and ponds in desertscrub communities (Table 9). Nesting density was greatest in mixed broadleaf riparian forest juxtaposed with chaparral although nesting occurred throughout all conifer and riparian communities except mesquite-saltcedar woodland (Table 11). Surface water was present within 1 km of 68 percent of nests. Ten species of trees were utilized for nesting (Table 12), and in general nests were placed in the dominant arboreal species in the stand. Compared with sympatric buteos, Cooper's Hawk nest stands had high densities of rather small, densely foliated trees (Table 10).

Food Habits

Observed Cooper's Hawk prey are presented in Table 14. Birds dominated the diet both numerically and by weight, however, it should be noted that 58 percent of observed prey items were collected from nests during the early nestling period when males do all hunting and bird prey are highly vulnerable (Snyder and Wiley 1976). Of 116 female prey, 68 percent were mammals, primarily cottontail rabbits (Sylvilagus spp.) and Harris' Antelope Ground Squirrels (Ammospermophilus harrisii). Snyder and Wiley (1976) reported 56.5 percent birds, 29.6 percent mammals and 13.9 percent reptiles in the diet of a breeding population of Cooper's Hawks in southeastern Arizona and southwestern New Mexico. Snyder and Wiley's data are strictly quantitative and probably provide a suitable representation of the breeding diet of the species in western Arizona. Of 187 winter prey items I identified, 45 percent were mammals, 51 percent birds and 4 percent were reptiles.

Breeding and Productivity

Reproductive statistics for 54 Cooper's Hawk breeding territories are summarized in Table 13. Pairs on 8 territories did not lay eggs and 7 territories in which eggs were laid failed to fledge young (13 percent of total). Four failures resulted when adults were shot, 1 nest was predated by an unknown mammal and eggs failed to hatch at 2 nests. Females were in immature plumage at 4 of the 7 failed nests, as well as on 7 successful territories. Successful nests with immature females hatched only 58 percent of eggs, compared with 88.5 percent overall.

My observations of clutch size, brood size and fledging success are somewhat lower than those reported for pre-DDT era Cooper's Hawks in eastern

and northcentral North America (Craighead and Craighead 1956, Schriver 1969, Henny and Wight 1972). Over most of the Cooper's Hawk's range high DDE levels have been noted in eggs, and associated egg breakage has apparently reduced productivity below stable population levels (Henny and Wight 1972, Snyder et *al*. 1973). The comparatively low productivity I observed does not appear to be related to pesticide contamination; egg breakage was noted at only 3 nests, all of which were tended by females in immature plumage and thus not likely to have accumulated large pesticide levels. Furthermore, compared with other populations (Craighead and Craighead 1956, Reynolds 1978) a high proportion (88.5 percent) of eggs hatched in nests I studied. An alternative hypothesis is that Arizona Cooper's Hawks lay comparatively smaller clutches as a rule than do more northerly populations. The tendency for clutch size to be larger in temperate than subtropical regions has been noted for a number of avian species with latitudinally broad ranges (Moreau 1944, Henny 1972, Henny and Wight 1972, Picozzi and Weir 1974, Huhtala and Sulkava 1976).

Clutches were set at 50 percent of nests by 25 April, with the earliest egg date 28 March. Incubation averaged 32 days at 4 nests, and eggs hatched in 50 percent of the nests by 29 May. Latest hatching date was 16 June. Fledging was variable, but at 6 nests all young had fledged an average of 31 days post-hatching (average 28 June). Young fledged from the latest nest about 14 July. There was no correlation ($r = 0.04$, $p > 0.90$) between date of egg deposition and elevation of nest, although nests in montane conifer forest averaged about 7 days behind those at lower elevations. Cursory observations at 3 territories in 1981, a comparatively dry year, indicated egg laying was 2 to 3 weeks later than that reported here.

Red-tailed Hawk

Taxonomy

Buteo jamacensis calurus and *B. j. harlani* were observed on the study area; *calurus* as a year-long resident and *harlani* as a rare autumn, winter, and spring transient. The species as a whole is highly polymorphic, and a wide range of *calurus* plumages-- from melanistic to pale (similar to *B. j. fuertesi*)--were commonly encountered. Melanistic or erythristic birds were present at 7 percent of nests located (n = 12 of 167), most in desertscrub communities. I have 3 *harlani* records; 1 pale-phased adult in March near Wikieup, 1 dark adult near Congress and 1 intermediate immature at Buckeye. Both latter records were in November. Subsequent discussion pertains only to the resident race *calurus*.

Distribution and Status

Common year-long resident in all plant communities. Some immatures may migrate but adults appeared to remain near nests all year (no attempt was made to retrap winter banded adults in spring). The larger winter population in many plant communities (Table 1 and 3) consisted mostly of immatures.

Red-tailed hawks exhibited the highest winter distributional diversity and second highest summer distributional diversity of any falconiform on the

study area (Tables 2 and 5). Evenness of distribution was similarly high in both seasons. The broad standard deviation around mean perch site measurements (Table 9) further elucidates the plasticity of this buteo with respect to habitat use. In general the species appeared to favor intermediate habitats--shrublands and grasslands with scattered trees--but red-tailed hawks also appeared highly tolerant of disturbance and were commonly observed in clearings on disturbed tracts in structurally extreme habitats. For example, the species was seldom observed in pristine riparian forests and montane conifer forest but was common in these communities near houses, clearings and power line corridors.

Breeding distribution was irregular in most communites and reflected the availability of suitable nest sites in open situations. Nests were located in trees, on cliffs and on power line distribution poles (Tables 11 and 12). Arboreal nests were typically situated in open stands of large mature or decadent trees or in lone trees (Table 10). Surface water was present within 1 km of 22 percent of nests.

Food Habits

Mammals, primarily lagamorphs and sciurids, dominated the observed diet of red-tailed hawks on the study area (Table 14). The species was clearly not restricted to mammalian prey and may prey to a heavier degree upon other vertebrates in dry years when small mammal populations are depressed (see discussion of abnormal climatic conditions observed during study period under Study Area). In a composite of data from across North America Snyder and Wiley (1976) reported the diet of this species to consist of 50.5 percent mammals, 36.8 percent invertebrates, 8.5 percent birds and 4.2 percent lower vertebrates.

Breeding and Productivity

Productivity statistics for 110 red-tailed hawk territories are presented in Table 13. Eggs were not deposited on 2 territories; 1 adult was in immature plumage at both. Ninety percent of territories successfully fledged young. Three failures were attributable to great horned owl (Bubo virginianus) predation, 4 to shooting of adults, 1 to removal of the nest and destruction of eggs from a power line tower, 2 to collapse of nests and 1 to unknown causes (probable predation).

Clutch size, brood size and fledging rates I observed are high compared to many other populations studied (Fitch et al. 1946, Craighead and Craighead 1956, Orians and Kuhlman 1956, Hagar 1957, Seidensticker and Reynolds 1971, Gates 1972, Johnson 1975, Wiley 1975, Smith and Murphy 1973, Smith and Murphy 1979). Mader (1978) studied reproduction of red-tailed hawks in the Sonoran desert of Arizona during a year of normal precipitation and observed an average clutch size of 2.32 eggs (per territory in which eggs were set). The high productivity I observed may reflect the abundance of mammal prey during the study period.

Clutches were set at 50 percent of red-tailed hawk territories by 5 March, with the earliest egg date 15 January. Incubation averaged 34 days at

5 nests, and eggs had hatched in 50 percent of nests by 12 April. Latest hatching date was 27 May. Young remained in nests an average of 48 days post-hatching on 5 territories, and young fledged at these sites between 15 and 28 May. Young fledged from the latest nest about 30 June. There was no correlation between date of egg deposition and nest elevation ($r = -0.031$, $p > 0.90$).

Swainson's Hawk

Taxonomy

Buteo swainsoni is monotypic. Like most buteos the species is polymorphic. Erythristic and melanistic adults dominated early autumn and spring migrant populations, with pale-phased birds and immatures appearing later.

Distribution and Status

Rare and local autumn and spring transient; more common in spring. Swainson's Hawks apparently summered and perhaps nested on the study area at least until the early 1900's; 2 adults collected in July by E. Jacot are on deposit in the University of Arizona collection. Both were taken in historic desert grassland habitats that were dominated by mesquite during the study period. Currently the species breeds in modest numbers in grama-mixed grass grasslands immediately north of the study area in Hualapai Valley (Millsap, Zook and Hall, unpublished data).

Autumn and spring transients concentrated near agricultural lands and were seldom observed in natural vegetation on the study area. Mortality from illegal shooting was high (4 specimens--all found illegally shot--were collected around Aguila and Buckeye). Extreme dates of observation were as follows: (1) autumn - 3 September and 19 October; and (2) spring - 4 March and 6 May.

Food Habits

Transients commonly foraged in agricultural fields. Four pellets examined contained only invertebrate remains (Coleoptera) although mammals, reptiles and birds are important elements of the breeding diet of the species elsewhere (Snyder and Wiley 1976, Sherrod 1979).

Zone-tailed Hawk

Taxonomy

The zone-tailed hawk, *Buteo albonotatus*, is monotypic.

Distribution and Status

Uncommon but widely distributed summer resident; absent in winter. Extreme dates of occurrence on the study area were 12 March and 3 October. Zone-tailed hawks typically appeared on breeding territories the first week of April. The zone-tailed hawk was generally restricted to broken,

mountainous terrain in westcentral Arizona and was observed with greatest frequency above 1,100 m elevation (Table 3). Distributional diversity and evenness were comparatively high (Table 4), reflecting the wide range of plant communities utilized. Observations from blinds suggest riparian habitats provided primarily nesting, roosting and resting cover and that most foraging occurred in adjacent uplands. Adults were observed foraging as far as 26 km from nests; most frequently over rocky, shrub covered slopes with no or few widely spaced trees. Topographic diversity appeared an important element of foraging habitat, although the species was occasionally observed foraging over relatively level grasslands and gently rolling paloverde-saguaro communities.

Nests were located in montane conifer forest, mixed broadleaf riparian forest and cottonwood-willow riparian forest. Montane conifer forest nests were in open stands of ponderosa pine on steep hillsides, and most riparian nests were in narrow, steep canyons in broken terrain. Surface water was present within 1 km of 61 percent of nests.

Breeding sites were widely dispersed, apparently reflecting the large foraging ranges occupied (Table 11). Nests were found in 4 species of trees (Table 12). Stands selected were variable in configuration; however, all nests located were situated on hillsides or immediately adjacent to cliffs or steep talus. Percent slope within 30 m of nests average 17.5 ± 6.1 percent, significantly higher than that observed for other sympatric raptors listed in Table 10 (t' test, $p < 0.01$ for all).

Food Habits

Observed prey of zone-tailed hawks are presented in Table 14. Data are a composite of blind and foraging observations and are probably highly quantitative. Mean prey weight was proportionally low compared with other falconiformes of similar size. This may reflect energetic limitations related to methods of hunting (see Brown and Amadon 1968) and distances traveled between nests and sites of prey capture.

Breeding and Productivity

Zone-tailed hawk productivity statistics are presented in Table 13. The rather small clutch size and high rate of hatching and fledging success is typical of many tropical and subtropical raptors (Newton 1977). Bent (1937) reported zone-tailed hawk clutches of 1, 2 or 3 eggs as typical, with 2 eggs the norm. I observed 3 clutches of 3 eggs and 2 nests fledged 3 young. No 1-egg clutches were observed.

Eggs were set in 50 percent of zone-tailed hawk nests by 1 May. Earliest egg date was 15 April and latest was 17 May. Incubation period was not determined precisely at any site but eggs had hatched in 50 percent of nests by 10 June. Eggs hatched in the latest nest about 27 June. Young fledged from 50 percent of nests by 28 July, and latest fledging date was about 10 August.

Ferruginous Hawk

Taxonomy

The ferruginous hawk, Buteo regalis, is monotypic.

Distribution and Status

Uncommon and local winter resident and rare summer resident. Winter records were concentrated near agricultural areas, particularly irrigated pastures along drainages. Northern pocket gophers (Thomomys bottae) were abundant in such situations and as many as 8 ferruginous hawks were observed feeding on gophers in 1 200 ha pasture. The hawk was rare in natural vegetation in winter and exhibited the lowest distributional diversity of any falconiform in this season (Tables 1 and 2). Perch sites selected by ferruginous hawks exhibited the lowest mean vegetation height and canopy volume index of any species studied (Table 9).

A substantial spring movement of ferruginous hawks was noted between 15 March and 5 April in 1979 and 1980. With the exception of possible nesters no ferruginous hawks were observed later than 20 April in either year. A defensive pair was located in June 1979 in desert grassland habitat near Bagdad, and a large nest lined with cow-dung was found in a nearby net-leaf hackberry. Eggshell fragments were found in the nest although it did not contain eggs or young when discovered. Breeding occurs sporadically in Great Basin/Great Plains grassland associations in northern Arizona; a nest was located in 1979 in a juniper savanna in northwestern Arizona (W. Luckett, pers. comm.) and a successful nest was found in a 4 m-tall catclaw in grama-mixed grass grassland in Hualapai Valley in 1981 (Millsap, Zook and Hall, unpublished data). The species nested historically in grassland habitat near Prescott and presumably elsewhere in eastern Arizona (Phillips et al. 1964).

Food Habits

No quantitative data are available from the study area. As suggested above, pocket gophers may comprise a substantial portion of the winter diet. In general, mammals (particularly lagamorphs and sciurids) are primary prey (Sherrod 1979).

Rough-legged Hawk

Taxonomy

Three subspecies world-wide; Buteo lagopus sancti-johannis occurs in North America.

Distribution and Status

Rare winter resident. One record from the study area, a melanistic individual on 11 January 1980 in creosotebush-bursage habitat near Tonopah. The southern limit of this species winter range appears highly variable. In

winter of 1980-1981 rough-legged hawks were regularly encountered in grassland habitat in Hualapai Valley, immediately north of the study area (R. Hall, pers. comm.). No observations of this species were recorded in this area the winter of 1978-1979 despite periodic coverage.

Harris' Hawk

Taxonomy

Two subspecies of Harris' Hawk occur in North America; *Parabuteo unicinctus superior* of Arizona, western Mexico and Baja California and *P. u. harrisi* of southern Texas, central Mexico, Central America and drier parts of western South America (Brown and Amadon 1968). *P. u. superior* occurs on the study area.

Distributional Status

Rare year-long resident of westcentral Arizona. After the species abandoned historic nesting sites along the Colorado River, it has only sporadically been reported north of New River (72 km north of Phoenix) and west of Phoenix (Whaley 1979). From my observations I believe the species occupied scattered nesting territories in especially well developed paloverde-saguaro communities in westcentral Arizona and also wintered widely in the same area. Although no nest sites were located, probable breeding records included 3 pairs in the vicinity of Wickenburg between 1 March 1980 and 10 May 1980 and 1 pair of defensive adults with recently fledged young on 22 May 1980 in an atypically diverse paloverde-saguaro community near Aguila. The most northerly record during summer was of a single individual on Burro Creek northwest of Bagdad on 6 May 1980 (J. Schnell and T. Allen, pers. comm.). Hanna et *al*. (1977) also reported Harris' Hawks from the Burro Creek area although nesting was not documented. Additional records included a pair north of Wikieup on 18 August 1980 (S. Ferrell and S. Jones) and 2 wintering individuals near Wickenburg on 30 January 1979 and 11 November 1979. Although seemingly suitable habitat exists in scattered tracts in westcentral Arizona the species has never been regularly reported in the region (Whaley 1979). Three factors may account for the recent apparent change in status: (1) the scattered and extremely local populations which existed were overlooked by previous workers; (2) widespread habitat destruction in the center of the species' breeding range (Whaley 1979) may have affected a northward and westward displacement of some population segments; or (3) expansion of the breeding range may be normal during wet years when mammal prey availability is high and previously unfavorable areas become temporarily suited to breeding.

Quantitatively, Harris' Hawks were the rarest falconiform on the study area in summer (Table 3). Although the species was only observed in summer and in the paloverde-saguaro community on quantitative counts, individuals were also seen in cottonwood-willow and mesquite-saltcedar communities. All observations were within 500 m of a perennial water source, suggesting water may be an important component of habitat for this species.

Food Habitats

No quantitative diet data were collected on the study area. Two wintering individuals were observed feeding on pocket gophers, and Whaley(1979) and Mader (1976) have reported Harris' Antelope Ground Squirrels and Gambel's Quail (Lophortex gambelii) as primary prey.

Common Black Hawk

Taxonomy

Buteogallus anthracinus anthracinus and perhaps B. a. gundlachii occur in the United States; the former in Arizona, New Mexico, Texas and Utah and the latter as an occasional vagrant in Florida (Carter and Wauer 1965, Wauer and Russell 1967, Webster 1976, Schnell 1979). B. a. anthracinus is the only race present in Arizona.

Distribution and Status

Locally distributed uncommon summer resident along some perennial streams with well developed broadleaf forest stands. The species was migratory; earliest spring record was 18 March and latest autumn record was 14 October. Adults usually appeared on breeding territories about 26 March. The species was almost entirely restricted to forested reaches of Burro Creek and its perennial tributaries during the study period, where 18 active nesting territories were located in 1979. One territory was located on Kirkland Creek in 1980 and another on the Hassayampa River north of Wickenburg in 1980. Black hawks were observed only in riparian forest plant communities (Table 3), and distributional diversity reflected restricted distribution (Table 4). Further, distribution within these communities was disjunct. Patchy distribution appeared in part to reflect biotic productivity in the riparian and associated aquatic system. On drainages where native catostomid fishes (a major prey item, Table 14) were absent (Kepner 1979, 1981) nesting was not observed, yet areas which afforded suitable piscine prey populations but appeared depauperate in amphibian and reptilian prey (other major prey types, Table 14) also did not support nesting black hawks. Presumably the species required a diverse array of both aquatic and semi-aquatic prey types. The presence of riffle, run and pool stream habitats may also be critical since many prey forms exhibit aquatic habitat preferences (Kepner 1979 and 1981, Millsap and Harrison 1981).

Black hawk nests were usually situated in rather large trees in mature, vigorous stands (Tables 10 and 12). Stands used were typically comprised of larger trees than those of Cooper's Hawks and had higher tree densities and greater canopy volume indicies than red-tailed hawks (Table 10). All nests were within 120 m of flowing perennial water, as discussed above.

Food Habits

Millsap and Harrison (1981) quantitatively reported the diets of 2 black hawk pairs on Burro Creek in 1980. These data have been recalculated and are presented in Table 14. Over 78 percent of this species' diet consisted of fish and psuedo-aquatic amphibians and reptiles. Few prey typical of upland plant communities were captured, indicating a nearly complete dependence upon riparian habitat for foraging.

Breeding and Productivity

Black hawk productivity statistics are presented in Table 13. Overall, mean clutch size, hatching success and fledging success exceeded that reported by Schnell (1979) for black hawks nesting on Araviapa Creek in southeastern Arizona. However, there were extreme differences in productivity between some territories on Burro Creek. One territory on Boulder Creek and 2 territories on Burro Creek downstream from the Boulder Creek confluence (see Fig. 2) fledged no young from initial nest attempts in 1979 and only 2 (from 6 eggs) in 1980 compared with an average of 1.6 per nest on other territories. Although clutch size at these sites did not differ significantly from that of the other 16 nesting attempts studied (t' test, $p > 0.75$), hatching and fledging success was significantly lower (t' test $p < 0.05$). Water quality studies have revealed high levels of copper and zinc in water, sediments and fish, frog and snake tissue samples from Boulder Creek and Burro Creek downstream from the Boulder Creek confluence. Heavy metal levels in upstream samples were normal and no pesticide residues were found in any sample (Kepner and Millsap, unpubl. data). Heavy metals apparently entered the drainage from existing and abandoned mines on Boulder Creek. Both copper and zinc exhibit biomagnification tendencies in aquatic systems (Lewis and Burraychak 1979), and it is possible these and perhaps other metals caused egg and nestling mortalities on affected black hawk territories in 1979 and 1980.

Clutches were set between 17 April and 20 May, with 50 percent of clutches completed about 5 May. One renesting attempt was observed after eggs of the first attempt failed to hatch. Incubation was approximately 37 days at 1 nest. About 50 percent of eggs had hatched by 11 June. Young remained in 2 nests for an average of 40 days post-hatching, and 50 percent of nests had fledged young by 21 July. The latest fledging date was about 6 August.

Golden Eagle

Taxonomy

Five races are recognized; Aquila chrysaetos canadensis is the form occurring in North America.

Distribution and Status

Uncommon and widely dispersed in upland plant communities in all seasons. Most frequently observed in desert grassland and chaparral (Tables 1 and 3). The species was slightly more common in winter, apparently reflecting an influx of migrant immatures and sub-adults in December and January. Distributional diversity and evenness were somewhat low in winter and higher in summer (Tables 2 and 4). This probably resulted from an uneven distribution of winter migrants among plant communities (weighted toward desert grassland) and a more equitable distribution of resident breeding adults. Golden eagles typically foraged in open habitats; either grasslands or steppe-like vegetation with scattered shrub cover (Table 9).

The distribution of breeding golden eagles was fairly consistent over the study area, with a pair in nearly every major mountain range which provided suitable cliff habitat. These breeding pairs foraged widely over surrounding valleys, and on several occasions peculiarly marked adults were observed 20 km from nests. Nesting density was greatest in the area north of Alamo Lake and south of the McCracken Mountains in extensive cliffs around Aubrey Peak and the Rawhide Mountains. Average distance between occupied nests in this area was 16.0 km while over the study area as a whole known adjacent active nests averaged 34.1 km apart. Assuming the latter figure to be representative and territories circular (see footnote a, Table 11), average density of breeding golden eagles was about 1 pair per 918.6 km^2. This is substantially more dispersed than populations in western Great Plains and Great Basin grassland/steppe habitats; estimated breeding densities in Montana, Utah, California, Idaho and Colorado range from 1 pair per 49.2 km^2 to 1 pair per 518 km^2 (Dixon 1937, McGahn 1968, Camenzind 1969, Kochert 1972, Olendorff 1973, Smith and Murphy 1979). My observations suggest suitable nesting sites were not a population limiting factor in western Arizona in contrast to observations by Boker and Ray (1971). It seems more likely comparatively low or unpredictable prey populations favored low nesting densities. Mean dimensions of cliffs used for nesting are given in Table 12.

Food Habits

Black-tailed jackrabbits (Lepus californicus) and cottontail rabbits were dominant prey (Table 14). Lagamorphs are common items of this species' diet over most of western North America (D'Ostilio 1954, McGahn 1966, Kochert 1972, Olendorff 1973).

Breeding and Productivity

Golden eagle pairs apparently do not breed each year in westcentral Arizona. Although prey populations were highly favorable during the study period, 15 percent of known pairs did not lay eggs (Table 13) and only 1 of 6 pairs studied attempted nesting 2 years consecutiely. Of pairs which did lay eggs, reproductive statistics compare favorably with most other studies (McGahn 1968, Beecham 1970, Kochert 1972, Olendorff 1973, Smith and Murphy 1979). Under normal climatic conditions with lower prey populations clutch size and mean number young fledged per nest would probably be lower and fewer pairs may attempt breeding (see Newton 1977, Smith and Murphy 1979).

Little specific data was gathered on chronology of nesting in this species. The earliest clutch observed was on 21 February and most pairs appeared to begin nesting in early March. The latest date eggs were seen in a successful nest was 8 May. Most young fledged in mid- to late June and early July. Compared with populations at more northerly latitudes nesting begins fairly late in western Arizona (Bent 1937). It is possible breeding is synchronized with typical rainfall patterns (e. g. summer rains in Arizona) and thus, reproductive periods of prey (see Ingles 1941, Fitch 1947, Sheffer 1958, Trethewey and Verts 1971, Turkowski 1975, McKay and Verts 1978).

Bald Eagle

Taxonomy

Two races are recognized; Haliaeetus leucocephalus leucocephalus which breeds in the southern and central United States and H. l. alascensis which breeds in Alaska and Canada (Brown and Amadon 1968). Subspecific distinction is marginal, and is based upon clinial size differences. Taxonomic status of the westcentral Arizona population is uncertain because both races may be present in winter and no specimen material is available from the area. The majority of wintering bald eagles observed at close range were relatively small in size; perhaps H. l. leucocephalus.

Distribution and Status

Uncommon and local winter resident on perennial streams and lakes; irregularly encountered migrant in all plant communities. Winter use was primarily centered on Burro Creek and Alamo Lake, where 12 individuals were counted in January 1980 and 14 in January 1981 (Millsap 1980, and unpublished data). Immatures and sub-adults were most common at Alamo Lake and adults dominated on Burro Creek in both years. A night roost used by at least 3 bald eagles in 1980 was situated in a grove of large cottonwoods near the confluence of the Santa Maria and Bill Williams Rivers. The roost was not used in 1981. At the time of use the site was less than 500 m from the shoreline of Alamo Lake, however, in 1981 the lake had receded and the site was over 4 km from water. Fish and waterfowl were probably important prey of bald eagles on the study area; about 20 percent of bald eagles seen were standing in water and 60 percent were perched over streams, beside large flowing pools or on lakeshores. Carrion may also be important, especially for sub-adults; at least 3 separate incidents of individuals feeding on burro carcasses were reported. Bald eagles apparently arrived on the study area in late November and departed in March and early April. The earliest sighting was on 21 November and latest 18 April. At least 3 eagles, 2 sub-adults and 1 adult, were present on Alamo Lake on 18 March 1979. Unsubstantiated reports of summering bald eagles on the Bill Williams drainage were received in 1979 and 1980, however, intensive nest searches were unproductive. At least 3 transient bald eagles remained at a small reservoir on Centennial Wash for several days in April, 1980. This site provided the only aquatic habitat for over 100 km, and these observations indicate small oases may provide important resting or feeding sites for migrants.

Northern Harrier

Taxonomy

Two races are recognized; Circus cyaneus hudsonius in North America and C. c. cyaneus in Europe and Asia. The former is present in Arizona.

Distribution and Status

Locally common winter resident and autumn and spring transient; rare and apparently sporadic nester. Harriers were observed in 5 plant communities in winter, with largest numbers seen in desert grassland and creosotebush-bursage (Table 1). Distributional diversity and evenness were intermediate (Table 2). Groups of 5 to 15 harriers roosted on the ground in agricultural fields (primarily stubble grain fields) and in galleta or tobosa tussocks along ephemeral washes. Winter harrier abundance was greatest close to communal roosts; presumably because individuals tended to forage nearby (within 10-20 km) and return to the same roost each night (see Watson 1979). The species typically hunted in open vegetation with scattered shrubs or trees (Table 9). Harriers were particularly common around the perimeter of agricultural fields.

In late March and April courtship flights were observed over communal roosts along Centennial Wash. Although nesting was apparently not attempted in this area, a nest with 3 eggs was found on 23 April 1980 near another communal roost on Cunningham Wash northwest of Hope. Eggs were deposited on a mat of red brome (*Bromus rubens*) near the edge of a large stand (2 ha) of big galleta and Johnson Grass (*Sorghum halapense*) surrounded by creosotebush and white bursage. Harriers have not been observed breeding in Arizona since 1890 when the species was an uncommon nester in eastern parts of the state (Phillips et *al*. 1964). Two factors may have contributed to favorable conditions for breeding in 1980: (1) the site used had not been grazed by cattle in over 20 years, and tall (1.5m) perennial grass cover was abundant on favorable soils; and (2) small mammal populations were at very high levels in 1980. Harriers are occasionally observed over much of Arizona in late spring and summer, and breeding under favorable conditions elsewhere might be expected. The nest found in 1980 was destroyed by land clearing operations before eggs hatched.

Food Habits

Two round-tailed ground squirrels (*Spermophilus tereticaudus*), 1 Harris' Antelope Ground Squirrel, 3 Merriam's Kangaroo Rats (*Dipodomys merriami*), 6 western meadowlarks (*Sturnella neglecta*) and 2 horned larks (*Eremophila alpestris*) were observed as harrier prey on the study area. Snyder and Wiley (1976) reported the diet of this species in North America as 48 percent birds, 35 percent mammals, 3 percent reptiles and amphibians and 15 percent invertebrates.

Osprey

Taxonomy

Five races, most marginal, are recognized; *Pandion haliaetus carolinensis* occurs in North America.

Distribution and Status

Uncommon autumn and spring transient and perhaps summer resident. Osprey were primarily observed as spring migrants on Burro Creek, at Alamo

Lake and along the Bill Williams River. One or 2 individuals apparently wintered at Alamo Lake in 1979. Spring records were concentrated between 1 March and 20 April. There were unconfirmed sightings of osprey at Alamo Lake during the summer of 1979, although no nests were found and reports could not be verified. The breeding status of this species in western Arizona is unclear. Regular nesting is restricted to high mountain lakes, but nests near large lakes and reservoirs in low deserts have been found (Phillips et al. 1964, Todd 1980). Apparently low elevation nesting is sporadic and may be primarily by inexperienced sub-adults and young adults under especially favorable conditions. Migrants were occasionally observed over uplands on the study area; 1 was seen near Aguila on 18 April 1980 and 1 in the Hualapai Mountains in mid-September 1980 (latter record R. Hall).

Food Habits

Osprey feed almost exclusively upon fish (Snyder and Wiley 1976, Sherrod 1979).

Common Caracara

Taxonomy

Five races are recognized; Polyborus plancus auduboni (following Brown and Amadon 1968) is the only race present in North America.

Distribution and Status

Accidental in western Arizona. Inclusion is based upon a single sight record. An immature was observed feeding upon fish (probably longfin dace, Agosia chrysogaster) in drying pools on the Santa Maria River near the Highway 93 bridge on 7 January 1981 by W. G. Kepner and the author. The breeding range of this species has been greatly reduced in Arizona since 1900, and nesting is largely limited to the Papago Indian Reservation currently (Phillips et al. 1964). Vagrants have been widely but irregularly reported in central Arizona: 1 in Phoenix, February 1971 (Snider 1971); 1 east of Gila Bend in winter 1972 (Monson 1972); 1 at Carefree, spring 1974 (Alden and Mills 1974); 1 near Phoenix, January 1976 (Witzeman et al. 1976); and 1 near Superior, April 1977 (Witzeman et al. 1977). The record on the Santa Maria River is perhaps the first for western Arizona north of the Gila River.

Peregrine Falcon

Taxonomy

Two of 3 North American subspecies may occur in Arizona; Falco peregrinus anatum comprises the breeding population in Arizona and F. p. tundrius (which breeds in artic regions of North America) may occur as a spring and autumn transient. Both sightings reported below were probably F. p. anatum based upon plumage characteristics.

Distribution and Status

Rare transient in autumn, winter and spring; may breed in isolated localities. Two individuals were observed, both in immature plumage. A dark peregrine was sighted flying over an extensive joshuatree-creosotebush formation in early March 1979 in the Sacramento Valley. The second individual was observed for several days in September 1980 in agricultural fields near Aguila. Both were apparently transients. Searches failed to reveal breeding peregrines although small amounts of suitable nesting habitat exist, particularly on Burro Creek. Additional intensive surveys should be conducted in this area before permitting extensive or large-scale developments.

Merlin

Taxonomy

Three North American races are recognized: Falco columbarius richardsonii;: F. c. columbarius; and F. c. suckleyi (Temple 1972). F. c. columbarius and F. c. richardsonii are long distance migrants and both may occur in winter on the study area (Brown and Amadon 1968). Most merlins observed were F. c. richardsonii but 1 adult male viewed for several minutes at close range was typical of F. c. columbarius.

Distribution and Status

Uncommon winter transient and perhaps winter resident in grassland communities (Table 1). The species was sighted in tobosa grasslands on mesas and in grama grasslands at the northern study area border but not in mixed grass-palmillia associations, perhaps by oversight. Observed individuals were either transients or ranged widely because none were observed more than once. Merlins were most often seen perched on low shrubs, fence posts and occasionally rocks. The habit of perching low made observation difficult, thus comparative relative abundance in Table 5 represents a minimal estimate. Most sightings were in open grasslands with few or scattered shrubs and trees. Dense, low to moderate height (.3 m to .5 m high) grass was present at most sites. Extreme dates of occurrence were 11 November (for F. c. columbarius; earliest observation for F. c. richardsonii was 12 December) and 26 March.

Food Habits

Sherrod (1979) and Snyder and Wiley (1976) report birds and invertebrates as primary prey. One individual on the study area was seen eating a house finch (Carpodacus mexicanus).

Prairie Falcon

Taxonomy

The prairie falcon, *Falco mexicanus*, is monotypic.

Distribution and Status

Uncommon yearlong resident on the study area. The species exhibited a decided preference for open habitats (Table 1 and 3). Distributional diversity was intermediate and evenness of distribution was moderately high in both winter and summer (Tables 2 and 4). Prairie falcons exhibited highest abundances in low and moderate elevation plant communities in winter and in higher elevation communities (e.g. desert grassland and interior chaparral) in summer (Tables 1 and 3). Autumn and spring "migratory" movements by prairie falcons are seldom over long distances and may be altitudinal (Bent 1938, Enderson 1964). Differences in seasonal distribution on the study area probably represent local vertical movements. Prairie falcons were most often observed hunting from elevated perches such as power line distribution poles and towers and leafless trees and snags. Areas hunted were seldom densely vegetated, and were dominated by cover less than 1 m tall (Table 9).

The species nested widely on cliffs throughout the study area, although most commonly in open habitats. Although cliff availability did not appear to limit nesting populations, nest density varied with cliff dispersion. Densest nesting was in isolated cliff areas surrounded by vast expanses of unbroken terrain. Where cliffs were uniformly dispersed nests were further apart. Closest active nests were 150 m apart and average distance between nests (in areas where all nests were probably found) was 10.5 $\pm$ 12.8 km. Nests were most often on metamorphic and sedimentary rock when available, although basalt cliffs were occasionally used. Mean dimensions of nesting cliffs are given in Table 12. Below 600 m elevation north facing cliffs were used more often and south facing cliffs less often than expected (X^2 = 6.74, $p < 0.01$). This probably reflected an effort to avoid high temperatures which undoubtedly occurred on south aspect cliffs in low deserts. There was no detectable bias in cliff selection by aspect at higher elevations (X^2 = .104, $p > 0.50$). Of 44 nests investigated, 9 (20 percent) were in stick nests built by other raptors, 29 (67 percent) were in potholes less than 1 m deep and 6 (13 percent) were in deep (> 1 m) holes, cracks and caves.

Food Habits

Observed prey of prairie falcons on the study area is summarized in Table 14. Snyder and Wiley (1976) reported invertebrates as more and mammals as less important prey than my observations indicate.

Breeding and Productivity

Reproductive statistics are summarized in Table 13. The proportion of pairs which did not lay eggs (13.3 percent) compares closely with that reported by Enderson (1964) for the species in Colorado and Wyoming and by Ogden and Hornocker (1977) in Idaho. Mean clutch size in westcentral Arizona, however, was smaller than that reported for populations at more northern latitudes (Tyler 1923, Webster 1944, Enderson 1964, Ogden 1973, Ogden and Hornocker 1977). As with the Cooper's Hawk, this may reflect a change in breeding strategy associated with latitude rather than environmental contamination or inadequate prey. Hatching success and estimated number of young fledged per nest were comparable with or exceeded that reported in the studies cited previously.

Clutches were set by 50 percent of prairie falcon pairs by 25 March; the earliest clutch recorded was on 8 March and the latest date eggs were seen in a successful nest was 18 May. Incubation was not determined, but apparently lasts from 29 to 33 days (Snow 1974). Young remained in nests about 40 days. Earliest fledging date was about 20 May and latest about 1 July. Young were fledged at 50 percent of nests by 5 June.

American Kestrel

Taxonomy

Fifteen races are recognized; Arizona is within the range of *Falco sparverius sparverius* (Brown and Amadon 1968). Occasional small pale individuals similar to *F. s. peninsularis* of southern Baja California and coastal Sonora and Sinalo, Mexico, were observed in the breeding population on this study area. There is probably intergradation between the races *F. s. sparverius* and *F. s. peninsularis* over much of the western Sonoran desert.

Distribution and Status

Common year-long resident in all plant communities (Tables 1 and 3). The American Kestrel was the most common falconiform in 5 plant communities in winter and 6 in summer. Distributional diversity and evenness were comparatively high in winter, and were the highest of any species in summer (Table 2 and 4). There was a marked change in distribution of sexes over the study area seasonally. In pinyon-juniper, chaparral and desert grassland communities females comprised 58 percent of the September population of this species, 21 percent of the November population, 2 percent of the January population and 41 percent of the April population. Conversely, in joshuatree-creosotebush, paloverde-saguaro and creosotebush-bursage communities females comprised 61 percent of the September population, 78 percent of the population in November, 86 percent in January and 52 percent in April. Apparently females migrated from higher altitudes of the study area in autumn; perhaps movements were local and altitudinal in nature. One

female banded near Aguila in December 1979 was found dead in the same area in February 1981; suggesting either some lowland-breeding females were sedentary or migrants returned to the same general wintering area each year. The former hypothesis seems most likely. Adult males were apparently sedentary; 2 banded in winter in desert grassland and 2 in creosotebush-bursage were retrapped in the same localities in summer.

Kestrels utilized a variety of habitats for hunting (mean vegetation values given in Table 9); however, sexes differed in vegetation structure at perch sites and general habitat use patterns. Vegetation around perches used by males had significantly greater mean canopy volume index values (t' test, $p < 0.001$) and mean canopy width measurements (t' test, $p < 0.05$) than perches used by females. Mean number of males seen in forested habitats per vehicle count day was significantly greater than mean number of females (t' test, $p < 0.001$), and mean number of females per count was significantly greater than mean number of males in open habitats (t' test, $p < 0.01$) (for this analysis forested habitats were defined as stands of arborescent vegetation more than 2 contiguous ha in size; open habitats were defined as agricultural fields, creosotebush-bursage formations lacking arborescent cover and desert grasslands lacking arborescent cover). Similar habitat segregation between sexes has been noted in other American Kestrel populations (for example Koplin 1973). Kestrels are readily sexed in the field, unlike many falconiformes (Brown and Amadon 1968), and thus present ideal subjects for study of intersexual relationships. Species less readily sexed, particularly highly size dimorphic falcons and accipiters, may also segregate sexually with respect to habitat use.

No attempt was made to study nesting of this species. Nevertheless, the species was found to be a widely distributed nester in all plant communities. Nests were found in cavities in ponderosa pine, aspen, Gambel oak, pinyon pine, juniper, cottonwood, ash, sycamore, Emory Oak, athel, joshuatree, paloverde and saguaro. Nests were also observed in buildings, cavities in arroyo walls and potholes in cliffs. Closest active nests were 750 m apart, and mean distance between 5 adjacent nests in the paloverde-saguaro plant community was 1.10 ± 0.60 km.

Food Habits

Observed prey are summarized in Table 14. Invertebrates, which comprise a large part of this species' diet (Snyder and Wiley 1976, Sherrod 1979), are probably under-represented.

Breeding and Reproduction

No specific breeding data were collected for this species. Copulation was frequently observed in late February and early to mid-March. Eggs were observed in 3 nests in saguaro between 15 March and 10 April. Four eggs were present in each nest examined. Fledged young were regularly observed in mid- and late May and early June.

FALCONIFORM POPULATIONS

General Trends

More species of falconiformes occurred on the study area than in other western North American localities which have been intensively studied (Craighead and Craighead 1956, Woffinden and Murphy 1977, Craig 1978, Wikinson and Debban 1980). Biogeographical factors were largely responsible for this high species richness. The study area is situated in a transition zone between the neartic and neotropical avian realms (Welty 1972), and species with affinities to each were present. Neartic species dominated, comprising 82 percent of winter and 77 percent of summer falconiform assemblages. All neotropical and many neartic species are near the edge of their ranges in westcentral Arizona (see Grossman and Hamlet 1964, Brown and Amadon 1968). Because of the peripheral nature and high species richness, local factors influencing distribution of individual species within the falconiform community are of particular interest.

Quantitative abundances of the 13 regularly encountered falconiformes are summarized by plant community in Tables 5 and 7. Using these values, habitat use overlap measurements (see Horn 1966) were calculated between each species pair. Simple weighted pair-group cluster analysis (Sokal and Sneath 1963) was employed to develop dendrograms illustrating distributional relationships (Figs. 5 and 6). In general, dendrogram groupings represent falconiformes associated with particular broad vegetation structures; that is, typical open-country (grassland) falconiformes (harrier, merlin, prairie falcon, golden eagle and ferruginous hawk) grouped together as did typical woodland species (Cooper's Hawk, goshawk, and sharp-shinned hawk). Furthermore, many of the species which grouped together tended to perch in structurally similar vegetation (see Table 9). This suggests physiognomic features of vegetation detectable at the plant community level greatly influenced falconiform distribution on the study area. Vegetation features (e. g. tree density, shrub density, vegetation height, grass and forb cover, species composition and vertical and horizontal heterogeniety to name a few) have often been cited as a proximate and perhaps ultimate factors affecting habitat selection (see Hilden 1965). Falconiformes as well as other avian species frequently exhibit strong morphologic adaptations to general vegetation types (see Wattel 1973, Karr and James 1975).

The red-tailed hawk and American Kestrel were exceptions to this rule. Although both species grouped more closely with woodland than grassland species, both were decidedly more common in intermediate vegetation types (i.e. grasslands with scattered cottonwood trees or channelized riparian forests where only a few trees remained). In reality these raptors appeared to comprise a unique group which overlapped strongly in distribution with both grassland and woodland falconiformes.

Diet is an important consideration in analyzing the distribution of any species over a geographic area. Data from the study area are insufficient to

examine patterns in detail, however, several general distribution trends were apparent. Forest and woodland plant communities were typically dominated by falconiformes which prey heavily on birds (see Tables 5 and 7) (diets of falconiformes are briefly summarized in species accounts). Hall (1980) reported highest estimated avian prey abundances in forested and woodland plant communities on the study area. Avian abundance and species diversity has been widely correlated with vegetation structural diversity, height and various aspects of foliage distribution in many plant communities; in general, the more vertically complex the community, the greater the avian diversity (see Balda 1975). Accordingly, the association between forested habitats and many falconiformes specializing on avian prey may in a broad sense reflect general trends in prey abundance. Similarly, open and structurally intermediate plant communities (chaparral, grassland and desertscrubs) were dominated by falconiformes which extensively, although not exclusively, prey upon mammals (Tables 5 and 7). Peck (1979) and Taylor and Walchuk (1980) demonstrated substantially higher abundances of many mammal prey species in these plant communities compared with forested or wooded communities on the study area. Thus, as with many avian prey specialists, falconiformes which prey heavily upon mammals exhibited associations with plant communities which supported large prey populations. As could be expected, the black hawk, which feeds primarily upon fish and pseudo-aquatic lower vertebrates, was strongly associated with riparian forest communities.

Correlations between habitat and diet overlap are also informative in assessing interspecific relationships; current niche theory predicts sympatric species which utilize similar vegetation structures will not overlap strongly in diet (see Cody and Diamond 1975). To briefly examine interspecific relationships on the study area I calculated diet overlaps at the major prey taxa level for the 13 regularly encountered falconiformes (quantitative diet data from Snyder and Wiley 1976, Sherrod 1979 and this study for black and zone-tailed hawks were used to compute overlaps). Overlap measurements were then partitioned by major prey taxa so the magnitude of diet overlap on mammals, birds, lower vertebrates and invertebrates could be determined for each species pair. Correlation coefficients were calculated between habitat and diet/partitioned diet overlap values in each season. The overall diet/habitat overlap comparison produced insignificant correlations in both seasons ($r = -0.09$, $p > 0.05$ for winter, $r = -0.02$, $p > 0.50$ for summer), however, several trends emerged from habitat/ partitioned diet comparisons. There was a significant inverse correlation between proportion of birds in diet and habitat overlap in both winter and summer ($r = -0.37$, $p < 0.02$ for both seasons). No relationship between proportion of mammals in diet and habitat overlap was discerned ($r = -0.02$, $p > 0.50$ for winter, $r = -0.08$, $p > 0.50$ for summer). Of the 2 prey groups available only in summer, there was no apparent association between proportion of lower vertebrates in diet and habitat overlap ($r = 0.19$, $p > 0.10$) but a positive relationship existed between proportion of invertebrates in diet and habitat overlap ($r = 0.37$, $p < 0.02$). Thus, species which prey heavily on birds tended to overlap little in distribution, species which prey heavily on mammals and lower vertebrates exhibited no consistent distributional relationships and species which prey heavily upon invertebrates tended to occur together.

Reasons for these results are speculative. Snyder and Wiley (1976) have discussed in detail demographic differences between avian, mammalian and invertebrate prey populations as they relate to raptorial predators. In general, mammal and invertebrate prey fluctuate tremendously in abundance from year to year with climatic variations while avian prey populations remain comparatively stable. Rottenberry and Weins (1980) have presented strong evidence that interspecific competition may be relatively unimportant in avian communities dependent upon widely fluctuating resources. Thus, raptors which feed upon irruptive prey may not experience selective pressure favoring evolution of static resource partitioning mechanisms. This may be particularly applicable in avifaunal transition zones where many components of the falconiform community are peripheral and perhaps irregular in occurrence. On the other hand, the comparative stability of avian prey populations from year to year would facilitate regular conditions of resource limitation and thus favor strong interspecific differences in utilization of avian prey populations. For example, Snyder and Wiley (1976) have presented evidence avian prey shortages may be a yearly occurrence near the end of the breeding season in temperate latitudes.

Alternatively, Storer (1966), Earhart and Johnson (1970) and Reynolds (1972) have suggested the agility of avian prey requires unique morphological specialization by their predators. Proportional length and shape of the tail and wing differ substantially between falconiformes which hunt birds in forests and open terrain (Brown and Amadon 1968, Wattel 1973). It follows that bird hunters adapted to forested environments would not be well suited to pursuit of avian prey in grasslands, and the opposite would be true of open country bird hunters. Thus, little opportunity for overlap in habitat may exist between these species. In contrast, falconiformes which hunt comparatively sluggish mammal and invertebrate prey typically exhibit less habitat-specific morphologies (see Brown and Amadon 1968, Wattel 1973), presumably because these prey are relatively easy to pursue in all but the densest vegetation and adaptions to particular vegetation conditions are not advantageous. Accordingly, many mammal and invertebrate hunters may be able to successfully use a wide range of vegetation types and structural conditions, and overlap between species in areas (or plant communities) of high prey availability may be common (see Marti 1974). Neither explanation is entirely satisfactory nor are they mutually exclusive.

Strong positive residuals resulted between some species pairs in avian, mammal and lower vertebrate partitioned diet/habitat comparisons. Because overlap between species in these cases was greater than models predicted, a more intensive examination of each case is instructive. In the winter bird/habitat comparison strong residuals resulted for the sharp-shinned hawk and Cooper's Hawk and Cooper's Hawk and goshawk. Storer (1966), Snyder and Wiley (1976) and Reynolds (1978) have studied the ecology of these congeners in areas of sympatry and noted significant differences in prey size between species; Reynolds (1978) considered the goshawk and Cooper's Hawk prey biomass maximizers and the sharp-shinned hawk a prey number maximizer. Additionally, sharp-shinned hawks in Oregon foraged primarily in the tree

canopy and the Cooper's Hawk and goshawk in shrubs and on the ground (Reynolds 1978). In general, the Cooper's Hawk appears to occupy a foraging niche intermediate between and, for the most part, discrete from those of goshawk and sharp-shinned hawk (Jones 1979).

In the winter mammal/habitat comparison large residuals resulted for the red-tailed hawk and ferruginous hawk and ferruginous hawk and golden eagle. Some differences in habitat use not apparent in earlier analyses existed between these species; ferruginous hawks occurred almost exclusively in open grasslands while both red-tailed hawks and golden eagles were more common in steppe-like vegetation or mesquite invaded grasslands (see perch data, Table 9). Nevertheless, all 3 species were observed hunting the same areas on occasion and segregation by vegetation structure was certainly incomplete. Prey size differences probably existed between the golden eagle and ferruginous hawk; however, both species have been shown to prey heavily upon sciurids and lagamorphs in areas of sympatry in the Great Basin (Smith and Murphy 1979). In the summer mammal/habitat comparison a high residual resulted for the Harris' Hawk and red-tailed hawk. These species overlap in distribution in the paloverde-saguaro plant community throughout much of the northern Sonoran desert. Mader (1978) and Whaley (1979) have commented that Harris' Hawks are for the most part restricted to relatively mesic, densely vegetated and structurally diverse paloverde-saguaro communities. Red-tailed hawks, although present in mesic desertscrub, become dominant in more xeric, structurally monotonous uplands and creosotebush valleys. This agrees with my observations on the study area. As in the case of the red-tailed and ferruginous hawk and ferruginous hawk and golden eagle, however, substantial overlap occurs in intermediate structural zones. More intensive study of these species in Arizona may reveal interspecific differences overlooked in this and other works.

In the lower vertebrate/habitat comparison a high residual resulted for the black hawk and zone-tailed hawk. These neotropical buteos were the only falconiformes which utilized this prey resource extensively, and little overlap in actual diet at the prey species level was apparent (Table 14). Zone-tailed hawks primarily preyed upon reptiles typical of upland plant communities (see Jones 1980, Jones et <u>al</u>. 1981) while black hawks preyed almost exclusively upon fish and psuedo-aquatic frogs and snakes. High habitat overlaps apparently reflected sympatric nesting in riparian forests and not overlap in foraging areas (see species accounts).

Above normal winter precipitation during the study period and associated abundance of many prey undoubtedly influenced falconiform populations. Accordingly, the preceding population assessment and other data in species accounts may not be pertinent in dry years. Newton (1979) has summarized available information which indicate during periods of prey shortage various raptor species may: (1) decrease in abundance (numeric response); (2) change diet (functional response); (3) not breed; (4) begin breeding later than normal; (5) lay fewer eggs; (6) fledge fewer young; (7) range further; and (8) change wintering localities. This list is not all-inclusive and any

species may evidence wide latitude in degree and types of response. Repetition of this study under drought conditions and monitoring reproductive history and diet of selected pairs of falconiformes for several years would be necessary to delineate normal ranges in each of the 8 parameters outlined above.

Land Use Impacts

As the previous general analyses suggest, vegetation structure and prey were primary elements influencing falconiform use of each plant community. Various land use activities alter structural characteristics of plant communities and prey base. Potential and observed impacts of the most apparent of these activities on falconiform populations are discussed below.

Livestock Grazing

Overuse of forage by livestock changes vegetation composition and structure of plant communities. Generally plant species most preferred and least resistant to grazing decrease in abundance with overuse while mobile annuals, unpalatable forbs and, in the absence of wildfires, woody shrubs and trees increase (Ellison 1960, Smith and Schmutz 1975). For example, increases in tree, shrub and unpalatable forb cover and decreases in perennial grass cover have been reported as a result of heavy livestock grazing in pinyon-juniper woodland (Arnold et al. 1964) and livestock grazing, control of wildfires and rodent activities have been cited as associated factors in mesquite and catclaw invasion of desert grasslands (Humphrey 1958, Smeins et al. 1976). Riparian communities are particularly susceptible to livestock overuse; in part because cattle and burros tend to concentrate in these habitats during summer months. This results in an uneven distribution of forage utilization, with heaviest and most persistent use in the vicinity of water. Overuse of riparian areas results in: (1) drastic reductions in reproduction of broadleaf tree species through grazing and trampling of seedlings; (2) removal of understory grasses and forbs which facilitates loss of established trees, arroyo cutting and/or channel spreading and braiding during floods; (3) destabilization of streambanks through vegetation loss and trampling; (4) widening and shallowing of the streambed which reduces habitat for larger fishes; (5) silting and sedimentation of cobble stream habitat; and (6) increased water temperatures and velocities (Alderfer and Robinson 1947, Packer 1953, Sharp et al. 1964, Smiens 1975, Marcuson 1977, Winegar 1977, Glinski 1977, Behnke and Raleigh 1979).

Long-term changes in vegetation and prey availablity induced by grazing produce associated changes in falconiform abundance, occurrence and productivity. For example, Millsap et al. (1980) reported the highest abundance of Cooper's Hawks in the chaparral plant community of westcentral Arizona in lightly grazed areas, lowest abundance in moderately grazed areas where shrub interspaces were devoid of vegetation and intermediate abundances in heavily grazed areas where invading shrubs such as catclaw and waitaminute bush (*Mimosa biuncifera*) filled interspaces. Cooper's Hawks nesting in

lightly grazed riparian/chaparral areas on my study area laid an average of 1.6 and hatched 1.4 more eggs than pairs in similar but heavily grazed regions. In addition, nests in lightly grazed areas fledged 1.1 more young than those where grazing was heavy. Differences in productivity were significant at all levels (t' test, $p < 0.05$). Presumably these observations reflected grazing induced reductions in shrub and ground oriented bird populations (see Overmire 1963, Page et al. 1978, Butler 1979, Reynolds and Trost 1980). On the other hand, grazing may initially increase populations of horned larks (*Eremophila alpestris*) and meadowlarks (*Sturnella* spp.) in grasslands (Owens 1971, Maher 1973 and 1979, Owens and Maher 1973, Skinner 1974 and 1975, Ryder 1975); both species were important prey of prairie falcons during the study period.

Many mammalian prey species may also increase in abundance as a result of livestock grazing, particularly in grassland communities where invaders such as mesquite and cacti provide browse and seeds for lagamorphs and rodents (see Vorhies and Taylor 1940, Reynolds 1958, Humphrey 1958, Peck 1980). Different species of falconiformes which prey upon mammals may be temporarily favored by grazing as succession from climax grassland to disclimax woodland proceeds. The Swainson's Hawk and perhaps the ferruginous hawk may be favored in early stages when isolated mesquite and catclaw stands provide perch and nesting sites in proximity to open foraging areas. Golden eagles and prairie falcons may also be benefited by tree and shrub perches at this and later stages. As shrub and tree densities increase, falconiformes tolerant of intermediate vegetation structures, such as red-tailed hawks and kestrels, are probably favored. The abundance of both these species in grasslands on the study area is indicative of the widespread semi-disclimax nature of this plant community in westcentral Arizona (Tables 5 and 7). In mesquite dominated disclimax associations woodland species like the Cooper's Hawk and in winter sharp-shinned hawks and goshawks probably become important elements of the falconiform community.

In riparian forests on the study area grazing has substantially reduced regeneration of many broadleaf tree species and created an imbalance in the age structure of arboreal elements (see Fig. 4). Data in Table 10 indicate nesting habitat was partitioned to some degree by arboreal platform building falconiformes in the cottonwood-willow plant community: (1) Cooper's Hawks typically nested in densely foliated stands of small trees; (2) black hawks typically nested in densely foliated stands of large, early mature to late mature trees; (3) red-tailed hawks typically nested in open stands of senescent and/or decadent trees; and (4) zone-tailed hawks used a wide range of stands on steep hillsides or on floodplains adjacent to cliffs. Thus, continued maturation of existing stands and the lack of regeneration will result in an increasing shortage of suitable nest stands for Cooper's Hawks and black hawks. In all probability this will produce a rapid decline in the breeding population size of both species. At least for the Cooper's Hawk, concurrent declines in avian prey abundance will accompany deforestation (see Anderson et al. 1979, Cohan et al. 1979). The lack of regeneration will also eventually affect declines in the zone-tailed hawk population, although

26 percent of nests I observed were in situations inaccessible to cattle and various age classes of trees were present. Red-tailed hawks, which appeared to prefer the open, decadent forests which result from grazing, will probably increase in abundance in the short-term as existing stands age; however, eventually tree nest sites will largely disappear for this species as well.

As a whole, the study area has had a long history of livestock grazing. Changes in vegetation structure outlined above were in evidence throughout the area. For example, BLM (1980) reported over 64 percent of range in the northern half of the area in fair or poor condition. Moderate grazing probably increases falconiform species richness in most plant communities by inducing a mosaic of seral and climax vegetation associations and promoting vegetation patchiness. However, many open country falconiformes are not favored by shrub and tree invasions in grasslands and chaparral, and few if any falconiformes benefit in the long-term from heavy livestock use of riparian areas.

Mining

Mining activities on the study area affect raptor populations directly via disturbance and habitat loss and indirectly through contamination of and removal of water from perennial streams. The latter factors are of particular significance; for example copper and zinc in Boulder and Burro Creeks downstream from a mined area appeared responsible for poor reproductive success among black hawks (see black hawk species account). Removal of water, both from surface and underground sources may result in decreased flows during droughts and loss or reduction of black hawk and bald eagle piscine prey populations (Millsap 1980). Ground water removal may lower subsurface water levels below the range of root systems of native phreatophyte vegetation along drainages (Brown et al. 1979b). In addition, this and other water use practices may favor deep-rooted saltcedar over native broadleaf tree species (Warren and Turner 1975). In conjunction with grazing, heavy water use probably hastens development of senescent forests in riparian corridors on the study area.

Erection of Power Lines

Perch availablility is a factor determining falconiform use. Although most falconiformes will hunt from flight, only the harrier and zone-tailed hawk appeared to do so as a rule on the study area. Other species generally hunted from perches. Marion and Ryder (1975) and Stahlecker (1978) have demonstrated significant differences in abundance of some perching raptors between power line corridors and undisturbed grassland in eastern Colorado; power poles and towers provided perches which were infrequently available in undisturbed areas. However, availability of perches can also reduce suitability of an area to some species. During this study vehicle counts were conducted on 28 days along an 18 km route in the creosotebush-bursage plant community. Nine km of the route paralleled a 500 kV power distribution line and the remainder was through adjacent similar but unaltered vegetation. Significantly greater numbers of American Kestrels, red-tailed hawks and

prairie falcons occurred along the power line corridor compared with the control area (t' test, $p < 0.05$ for all), and significantly more Cooper's Hawks (which typically perched on low shrubs and trees) and harriers were observed in the control area (t' test, $p < 0.05$ for both). Of the total number of raptors observed, 78 percent were along the power line corridor, however, species diversity was substantially greater in the control area ($H' = 0.96$ in corridor, $H' = 1.47$ in control).

Disturbance

Although disturbance (used loosely in this case to include any form of human presence which may interfere with normal activities of falconiformes; for example roads, trails, houses, utility corridors, agricultural activities, recreational sites and construction activities) does not always involve changes in vegetation or prey base, it does influence falconiform use of an area. Tolerance to disturbance varies from species to species and between individuals, however, human interference and activity has resulted in abandonment of nests and territories by accipiters (see White 1974), ferruginous hawks (Howard and Powers 1973, Olendorff 1973, Smith and Murphy 1973), golden eagles (Boker and Ray 1971, Murphy 1973) and black hawks (Schnell 1979) to name a few.

On the study area red-tailed hawk nests averaged significantly closer to areas of human disturbance (805 ± 108 m) than those of any other species tested (Cooper's Hawk, black hawk, zone-tailed hawk, golden eagle and prairie falcon) (t' test, $p < 0.05$ for all). American Kestrels also nested in heaviy disturbed areas but too few sites were located for analysis. Among other species mean distance between nests and disturbed areas was: (1) golden eagle $18{,}061 \pm 1{,}080$ m; (2) zone-tailed hawk $16{,}113 \pm 1{,}021$ m; (3) prairie falcon $12{,}134 \pm 1{,}889$ m; (4) black hawk $1{,}695 \pm 306$ m; and (5) Cooper's Hawk$1{,}411 \pm 199$ m. Presumably these data are somewhat reflective of the tolerance of each species to human presence. Increased human activity in relatively undisturbed parts of the study area, if persistent, may cause abandonment of territories by relatively intolerant species and result in a locally less diverse falconiform population. Short-term disturbance, such as that which occurs with ORV races, pipeline construction, road repairs and well construction, may result in failure of nearby nests if adults are kept away for long periods (eggs or young may chill, overheat, desicate or be predated)(Berry 1980). However, if these activities are not repeated on a yearly basis during crucial periods of the nesting cycle, abandonment of the territory is unlikely. In general, falconiformes are most sensitive to disturbance immediately prior to and during egg laying and incubation periods (Call 1978).

The impacts of disturbance in hunting areas has not been well described, although presumably species relatively intolerant of nest disturbance also prefer undisturbed hunting areas. In the case of upland nesting species disturbance of productive hunting sites may be as, or more, detrimental than nest disturbance. Considering rapid increases in use of public and state lands on the study area this topic deserves further study.

MANAGEMENT RECOMMENDATIONS

Priority Species

The Endangered Species Act of 1973 as amended and the Federal Land Policy and Management Act of 1976 mandate management of wildlife habitat on public lands (Olendorff and Zeedyk 1978). Perhaps the most specific management directives pertaining to falconiformes are contained within the Endangered Species Act (as per BLM Draft Manual 6840). The basic intent of the act is to recognize species whose status is threatened or endangered and through protection or management increase populations to levels where special concern is no longer necessary. BLM Draft Manual 6840 also identifies the need to provide similar consideration to wildlife species listed as threatened, endangered or unique by state wildlife agencies and species considered sensitive by BLM state offices. Fourteen of the 22 falconiformes present on this study area are considered threatened, endangered, unique or sensitive; thus, a priority management objective is the delisting of these species.

Because the presence of a species on the federal, state or BLM list confers a serious commitment to active habitat management, it is imperative lists contain only those species deservant of special status so limited management funds can be utilized most efficiently. Status information provided by this and other recent studies indicate several listed species may no longer or perhaps never were at population levels requiring special concern. Data also identify several candidate species for sensitive or state threatened status. Proposed status changes, management recommendations (based upon data and conflicts outlined in preceding sections) and additional data needs have been summarized for pertinent species below.

Mississippi Kite (Status - Listed as unique by AG&FC)

Because the study area is largely out of the current range of this species in Arizona, the Mississippi Kite should not be considered a priority management species on the study area.

Goshawk (Status - BLM Sensitive)

Although restricted as a breeding species to boreal islands in western Arizona, the northern goshawk apparently has a denser, more contiguous distribution in montane forests of the eastcentral and central parts of the state (see Phillips et *al*. 1964, Luckett 1977). In addition, northern Rocky Mountain populations (to which many wintering goshawks in western Arizona presumably belong) are apparently stable (Shuster 1977). Accordingly, the northern goshawk should be dropped from the BLM sensitive species list in Arizona. The status of the Apache goshawk is unclear. More definitive taxonomic studies are needed to determine the validity of the race, and field studies should be conducted to ascertain distribution and status. Until data becomes available *A. g. apache* should be retained on the BLM list.

Preservation of existing goshawk breeding populations on the study area should remain a management goal. The unique floral and faunal associations which comprise boreal islands are of considerable scientific and aesthetic value, and the northern goshawk is an important element of these ecosystems (see van Rossem 1936, Johnson 1965). The following management recommendations, in order of priority, are suggested:

1. Limit developed recreation to existing sites in the Hualapai Mountains. A biologist familiar with raptors in conifer forests should assist in the planning of any expansion of existing facilities.

2. Route roads, power lines and other easements away from forested areas and adjacent to existing corridors whenever possible.

3. Establish 4, 4 ha livestock exclosures in the Hualapai Mountains above 1,800 m elevation. Exclosures should be situated within 0.5 km of suitable nest stands and constructed along forest edges in openings.

4. Limit timber and woodcutting above 1,700 m in the Hualapai Mountains. Have a wildlife biologist familiar with goshawk ecology inspect all timber harvest proposals. Luckett (1977) has provided timber management recommendations for goshawks in Arizona ponderosa pine forests.

5. Through land exchanges, BLM should attempt to acquire additional forested land in Hualapai Mountains.

6. Determine physiognomic characteristics of goshawk nest stands and foraging areas and investigate possibilities of creating additional suitable habitat through active management.

7. Through additional surveys and monitoring determine population size and reproductive success of goshawks in the Hualapai Mountains. Surveys should be conducted prior to implementation of #5 to aid in effective land selection.

Sharp-shinned Hawk (Status - BLM Sensitive)

The breeding status of the sharp-shinned hawk (*A. s. velox*) in Arizona is imperfectly known although it is doubtful populations are decreasing. Hubbard (in Tate 1981) reports the species as stable in New Mexico, and the same is probably true in eastern Arizona conifer forests (see Snyder and Glinski 1978). Counts of migrants in eastern North America have remained relatively stable since 1960 (Nagy 1977). Accordingly, the subspecies *velox* should be dropped from the BLM sensitive species list. Pending additional status investigation, the subspecies *A. s. suttoni* should remain on the sensitive list.

As with the goshawk, preservation of existing sharp-shinned hawk breeding populations on the study area should remain a management goal.

Goshawk management recommendations would benefit sharp-shinned hawks with the following additions in order of priority:

1. Establish 3 additional 4 ha livestock exclosures in Gambel Oak-walnut riparian forests above 1,900 m elevation in the Hualapai Mountains.

2. Determine physiognomic characteristics of sharp-shinned hawk nest stands and foraging areas and investigate possibilities of creating additional suitable habitat through active management.

3. Through additional surveys and monitoring determine population size and reproductive success of sharp-shinned hawks in Hualapai Mountains.

Cooper's Hawk (Status - BLM Sensitive)

Although the Cooper's Hawk is the most common accipiter in Arizona, analysis of data from the study area indicate livestock grazing activities have probably affected population declines. Eighty-seven percent of nests located were in riparian habitats, and 78 percent of these sites were grazed heavily by livestock. Although elimination of livestock and burro grazing in riparian areas is the optimal solution to population declines by this and other riparian breeding falconiformes, this is unlikely to occur on the study area. As a result, further population declines are likely. The Cooper's Hawk should remain on the BLM sensitive list.

Active management for this species should be directed toward mixed broadleaf and cottonwood-willow riparian forest communities. Specific management localities are not given in order to protect existing nest sites, however, general management recommendations in order of priority include:

1. Erect 1, 1 ha livestock and burro exclosure every 3 km along streams where nesting was documented. Exclosures should be monitored regularly (particularly after floods) and repaired immediately if damaged. Shape of exclosures should be rectangular with the long edge parallel to the streambed.

2. Plant cottonwood cuttings in exclosures near marginal Cooper's Hawks nest stands. Plantings should be in elongate stands parallel to streams and situated along the edge of stream beds. Cottonwoods should be planted in 0.25 ha of the exclosure at an average density of 1 tree per 15 m^2 (8 m between trees; this involves planting 40 cuttings). Stands should be thinned to an average density of 1 tree per 11 m^2 (30 trees) 2 years after planting.

3. Limit developed recreation to existing sites in riparian plant communities. Do not permit off-road vehicle activity in stream floodplains.

4. Route utility easements at least 1 km away from riparian corridors. Where stream crossing is necessary, power line, pipeline or road crossings should be perpendicular to corridors to reduce extent of habitat loss.

5. Monitor reproduction, pair fidelity, nest locations and diet of Cooper's Hawks on 5 territories in cottonwood-willow forest and 5 in mixed broadleaf forests for a 3-year period. Six territories should be in unmanaged areas with varying degrees of livestock use and 4 should be near the exclosures in heavily grazed areas. Vegetation measurements should be taken yearly around active nests, nests used in previous years and within livestock exclosures. Data should be analyzed with an emphasis upon delineating additional management recommendations and assessing effectiveness of exclosures and plantings as management tools for this species.

Zone-tailed Hawk (Status - Listed As Threatened By AG&FC)

Data from this study indicate the zone-tailed hawk is widely distributed in montane habitat in westcentral Arizona. Low population densities are probably typical of the species and do not reflect a lack of suitable habitat. Snyder and Glinski (1978) report similar findings in southeastern Arizona. Accordingly, threatened status is questionable a more intensive review of this species' status in Arizona is needed.

Livestock grazing and disturbance in riparian and montane conifer forests has undoubtedly reduced the quality of many zone-tailed hawk nest sites. Management recommendations 1, 2, 4 and 5 for goshawks and 3 and 4 for Cooper's Hawks will also benefit the zone-tailed hawk. Additional management recommendations include:

1. Plant cottonwood poles in riparian plant communities adjacent to cliffs or steep talus near floodplain-upland ecotones. Plantings should be situated in areas where early morning sun will strike the nest grove. R. Glinski (pers. comm.) has accumulated data which shows many zone-tailed hawk nests in Arizona are located near turkey vulture roosts, supporting the theory zone-tailed hawks may be an active vulture mimic (see Snyder and Glinski 1978). Situating plantings near known vulture roost sites or sunning areas may increase likelihood of eventual use by the hawk for nesting. Plantings should consist of 10 poles spaced an average of 30 m apart. Stands should be thinned to 6 trees 2 years after planting. Plantings will probably not require fencing if poles are of suitable size (approximately 3 m above ground surface once planted), however, stands should be monitored closely to determine if livestock damage is occurring.

2. Exclude livestock from springs supporting cottonwood growth in the Aquarius, Weaver, Hualapai and Poachie Mountains.

3. Monitor reproductive performance and food habits and determine foraging ranges and habitats of zone-tailed hawk pairs on 5 territories

over a 3-year period. Analyze data with an emphasis upon delineating management recommendations for foraging areas.

Ferruginous Hawk (Status - BLM Sensitive)

The ferruginous hawk, although a regular winter resident, is apparently a rare and patchily distributed nesting species in Arizona. Breeding distributional status needs to be thoroughly investigated, particularly in northeastern Arizona grasslands. If breeding populations are as low in northeastern as in northwestern Arizona, the species should be placed on the AG&FC threatened list. The status of this species is in question throughout much of its range, and populations appear to have declined in Oregon, Washington, New Mexico and Utah (Tate 1981).

Although the species has probably never nested regularly on the study area, grama-mixed grass associations near the northern periphery of the study area could provide suitable nesting areas if range conditions improve. The following recommendations are suggested:

1. Establish a controlled burning program in grassland habitat immediately north and east of the Hualapai Mountains. Prescribed burns should be designed to remove snakeweed and woody shrubs and trees and restore perennial grasses. Small stands of juniper or catclaw should be excluded from burns to provide isolated nest and perch sites.

2. Erect 2, 1.0 km^2 livestock exclosures in burn area.

3. Route utility corridors around managed area.

4. Erect 2, 1.0 km^2 livestock exclosures on Goodwin Mesa.

Harris' Hawk (Status - None)

The status of this species should be carefully monitored. Whaley (1979) reported the species as extirpated from much of its former range in Arizona, and recent land developments have or will consume several productive Harris' Hawk habitats within the existing range of the species. The species is or will soon be a candidate for the state threatened list. Until a comprehensive status review can be undertaken, the Harris' Hawk should be considered sensitive by BLM.

The primary management consideration should be protection of existing paloverde-saguaro formations supporting Harris' Hawk populations from development. Overuse of forage by livestock probably reduces populations of many prey species, and establishment of grazing exclosures in high-density areas would be beneficial.

Black Hawk (Status - Listed as Threatened by AG&FC)

Data from this study support retaining this species in the threatened category of the AG&FC list. The general downward trend in riparian habitat condition resulting from grazing and mining activities are producing black hawk population declines on the study area. Elimination of livestock grazing in riparian habitat along Burro Creek would greatly benefit this species, however, this is unlikely to occur and other management activities are necessary. In addition to recommendations number 3 and 5 for Cooper's Hawks, the following activities will benefit black hawks:

1. Construct 1 ha livestock and burro exclosure near black hawk nest sites on Burro Creek and perennial tributaries.

2. Plant cottonwood saplings in an elongate stand (with long side parallel to stream) 80 m wide by 100 m long in exclosures. Trees should be planted an average of 17 m apart (will require 30 trees). Stands should be monitored yearly, and unhealthy or dead saplings should be replaced. Saplings should be as large as practical when planted.

3. Encourage enforcement of state and federal water quality regulations on Boulder Creek. Develop a plan to periodically monitor water quality downstream from mine areas. Continue monitoring of black hawk productivity on Burro and Boulder Creeks. If egg hatchability does not improve in contaminated areas, arrange to collect unhatched eggs for heavy metal/pesticide analyses.

4. Conduct instream flow studies on Burro Creek to ascertain water requirements of reptile, amphibian and piscine prey species. Calculate optimal instream flow values and file for rights to amount of water necessary to maintain needed flow.

5. Construct isolated temporary pools to increase leopard frog (<u>Rana pipiens</u>) populations in the streambed on each black hawk territory on Burro and Francis Creeks. Pools should be at least 1 m deep and situated apart from the main stream channel. Pools should be constructed in February or March and could be built by 2 persons with shovels. Preferably, pools should be situated under suitable perch sites and in localities where shade will be present on late summer afternoons.

6. Through habitat monitoring, determine physiognomic characteristics of black hawk nest stands and foraging areas (including characteristics of the aquatic system) with an emphasis upon delineating additional management needs.

Golden Eagle (Status - BLM Sensitive)

Much of the study area appears marginal for this species, as was evidenced by wide spacing of nests and apparent low productivity. For these

reasons the species deserves special management consideration and should be retained on the BLM list.

Protection of existing nesting areas should be a primary management consideration. Potentially disturbing activities should not be permitted within 1 km of nest sites between 15 January and 1 May, and activities should not be permitted within 0.5 km of nests between 2 May and 30 June (see Suter and Joness 1981). General recommendations for priority plant communities (given later) will also benefit this species.

Bald Eagle (Status - Listed as endangered by Secretary, U. S. Dept. of the Interior)

In general, black hawk management recommendations will also benefit the bald eagle on the study area, however, more data are needed before adequate management can be initiated. Specifically, roost sites of bald eagles wintering on Burro Creek should be located and protected if possible. Vegetation around roost sites and vegetation and stream characteristics at hunting perches should be measured and analyzed to determine possible habitat management opportunities. In addition, BLM should pursue a joint study with Arizona Game and Fish Department and U. S. Fish and Wildlife Service to color band bald eagles on Burro Creek in an effort to determine: (1) the origin of the wintering population; and (2) fidelity of individual eagles to the Burro Creek wintering area.

Osprey (Status - listed as Threatened by AG&FC)

Data from the study area are insufficient to comment on status. Habitat management recommendations for the black hawk and bald eagle will also benefit this species.

Caracara (Status - Listed as unique by the AG&FC)

The study area is out of the typical range of this species. Active management is not recommended unless the caracara becomes a more regular component of the raptorfauna of westcentral Arizona.

Peregrine Falcon (Status - Listed as endangered by Secretary, U. S. Dept. of the Interior)

Potential peregrine falcon habitat should be inventoried intensively before permitting potentially disruptive developments. If breeding falcons are located, the area within 2 km of the cliff should be closed to disturbing activities between 15 January and 15 July. General recommendations for priority plant communities (given later) will also benefit this species.

Merlin (Status - BLM Sensitive)

No change in status is recommended for either subspecies. Management recommendations for the ferruginous hawk will benefit merlins as will general guidelines for grassland plant communities (given later).

Prairie Falcon (Status - BLM Sensitive)

Data indicate the prairie falcon is widely distributed throughout the study area at moderate densities. Several land use activities, including grazing and utility corridor development, may actually benefit this species. Accordingly, the prairie falcon should be deleted from the BLM sensitive list in Arizona.

Priority Plant Communities

Although it is necessary to specifically manage habitat for the priority species discussed above, a broader ecosystem management effort is also needed to reduce the probabilities of having to list additional species. As data presented earlier imply, the variety of vegetation structural conditions available in each plant community contributed to high species richness on the study area. Strategically increasing structural variability in key plant communities is an important management objective. Tables 5-8 provide falconiform population statistics for each plant community. Using these data plant communities can be ranked on a priority basis using diversity (H') statistics and number of species present (species richness). In winter plant communities rank in the following order (priority from high to low): (1) desert grassland and chaparral; (2) creosotebush-bursage (3) paloverde-saguaro (4) mesquite-saltcedar woodland; (5) joshuatree-creosotebush (6) pinyon-juniper; (7) mixed broadleaf forest; and (8) cottonwood-willow forest. Plant communities rank in the following order in summer: (1) montane conifer forest; (2) cottonwood-willow forest; (3) desert grassland; (4) chaparral and mixed broadleaf forest; (5) paloverde-saguaro and creosotebush-bursage desertscrub; (6) mesquite-saltcedar woodland; (7) joshuatree-creosotebush desertscrub; and (8) pinyon-juniper.

Based upon priority rankings, ecosystem management activities directed at montane conifer forest, cottonwood-willow forest, mixed broadleaf forest, desert grassland, chaparral and creosotebush bursage plant communities will be most effective in maintaining species richness. Because land use activities (see Falconiform Populations, Land Use Impacts) greatly influenced falconiform occurrence and abundance, a long-term land use activity management program designed to increase habitat variability is recommended. General management guidelines for key plant communities are given below.

Montane Conifer Forest

An intensive fire management plan, which includes prescribed burning in existing mature forests, should be developed for the Hualapai Mountains. The plan should be designed with primary emphasis upon stimulating conifer regeneration, reducing shrub cover and increasing perennial grass cover above 1,700 m elevation. Burning and other management activities should be conducted between 1 September and 15 February to avoid disrupting nesting raptors.

A recreation management plan should also be developed for the area. Recreation pressure undoubtedly will increase in the Hualapai Mountains, resulting in greater opportunities for disturbance induced nest abandonment. Encouraging use of existing developed recreation sites rather than dispersed recreation will reduce disturbance, but as use increases it may become advisable to close some areas to recreation between 15 April and 15 June. Construction of trails which avoid important raptor use areas may also be beneficial.

Livestock use should be reduced over most of this plant community to allow range conditions to improve. Small exclosures, such as those recommended for the goshawk and sharp-shinned hawk, should eventually be implemented throughout the Hualapai Mountains to increase habitat variability and provide a natural and dependable perennial grass seed base.

Chaparral and Desert Grassland

During the study period both communities were dominated by the red-tailed hawk and American Kestrel; species associated with intermediate vegetation structures. Accordingly, management should be directed toward increasing the extent of open, treeless habitat in grasslands and perennial grass and climax shrub cover in chaparral. The most effective means of creating structural conditions desired is through extensive (5-10 km^2) prescribed burns and resting from grazing. Burning over several successive years may be necessary to kill woody vegetation in grasslands; however, in chaparral opening shrub interspaces to grasses and not destruction of climax shrubs (e.g. shrub live oak and manzanita) should be the desired goal. Reseeding, if necessary, should be with native perennial species only. Burns in grasslands should be designed to leave isolated trees or tree stands which will serve as falconiform nest and perch sites. Where burning is not practical or deemed unnecessary 0.25 km^2 livestock exclosures should be constructed and interspersed throughout the community to provide "islands" of dense vegetation which will support high densities of many prey species. If hunting perches or nest trees are unavailable near exclosures, 1 or 2 dead trees or live plantings should be anchored or placed along edges. Artificial nest platforms should not be placed in exclosures. Artificial platforms may attract great horned owls and discourage nesting by target platform building falconiformes such as ferruginous hawks and Swainson's Hawks.

Potentially disruptive land use actions should be scheduled during periods when raptor nesting activities will not be adversely impacted. Activities should not be permitted between 15 February and 30 April within 1 km of golden eagle and prairie falcon nesting areas. Only minor activities should be allowed within 0.5 km of nests between 1 May and 30 June. Similarly, areas within 0.5 km of forested riparian areas should be closed to disturbing activities between 15 March and 15 June, and only minor activity within 0.25 km is advisable between 15 June and 15 July.

Creosotebush-bursage Desertscrub

Throughout much of this plant community perennial grass and forb cover have been overutilized by livestock, resulting in a structurally monotonous shrub community. Grazing exclosures (1.25-2.5 ha in size) along ephermeral washes with productive, sandy soils would permit establishment of galleta "pastures" such as that used by northern hariers for nesting during this study. As in desert grassland and chaparral communities, exclosures would also serve to create locally high and predictable prey populations which would benefit a number of falconiform species.

Disturbing activities should not be permitted between 15 February and 30 April within 1 km of golden eagle and prairie falcon nesting areas. Only minor activities should be allowed between 1 May and 30 June within 0.5 km of nests.

Mixed Broadleaf and Cottonwood-willow Forests

Most falconiformes restricted or largely restricted to riparian forest plant communities on the study area are of management priority. Accordingly, these plant communities are of highest management concern. Although management recommendations have been given for individual species, those dealing with mitigation of grazing impacts are temporary and will not solve the problem of declining riparian habitat quality. A temporary moratorium on livestock grazing on Burro Creek needs to be implemented if the status of the black hawk is to be maintained or improved on the study area. During the moratorium period experimental grazing of isolated pastures during different seasons and at different intensities should be conducted. Response of cottonwood seedlings to different grazing schemes should be carefully monitored. After a period of 5 years data should be analyzed, and recommendations for proper multiple-use management of these plant communities developed. Grazing systems designed via this monitoring effort should be incorporated elsewhere on the study area.

Disturbance in riparian forests should be carefully regulated on a case-by-case basis. In general, important riparian and terrestrial habitats within 0.5 km of Burro Creek should be closed to major activities between 1 December and 15 February to provide seclusion to wintering bald eagles and

between 15 March and 30 June to protect breeding black hawks; the latter period is most crucial. Only minor activities should be allowed within 0.25 km of these areas between 30 June and 30 July. Elsewhere, activities within riparian forests and adjacent terrestrial habitat within 0.5 km should not be scheduled between 15 March and 15 June. Recreational use of riparian forests, particularly on Burro Creek, should be monitored. Selected areas around black hawk, zone-tailed hawk and Cooper's Hawk nests may eventually need to be closed to some recreation activities between 25 March and 10 May if use increases.

Other Management Considerations

Artificial Perch and Nest Provision

Considerable attention has been given to increasing populations of some falconiformes through providing artificial nesting and perching sites (see Olendorff et al. 1980 for review). The impact of this form of management on the falconiform population as a whole is seldom considered. For example, placing several perch snags in livestock exclosures on the study area may inhibit use of the area by harriers for roosting or breeding, and the impacts of providing power line perches in the creosotebush-bursage community has been described in a previous section of this paper. Thus, although a useful management tool, the objectives and impacts of using artificial perch and nest sites need to be carefully delineated before and monitored after implementation.

Providing nesting boxes and platforms on power line easements should be a standard procedure. Red-tailed hawks construct nests on 3-phase poles around insulators and in latticework on towers. Provision of artificial platforms in safe localities on structures would reduce chances of damage to equipment. Kestrel populations would benefit from provision of nest boxes along corridors in open habitats. As a general rule, providing 1 platform and box every 2 km is sufficient. It should be noted this will not mitigate loss of habitat for species which avoid power line corridors. Without exception new power line easements should always be routed adjacent to existing corridors to minimize alteration of additional terrain.

The use of artificial nest structures to increase ferruginous hawk populations along the northern periphery of the study area is not advisable until other management recommendations are implemented. If prescribed management fails to increase the breeding population, dead juniper snags should be erected in a few strategic localities. Nest platforms (see Call 1978) should be constructed in an open crotch between 2.5 and 4 m above ground. Situate platforms such that limbs will shade 25 to 30 percent of the nest at mid-day.

Information Management

Effective raptor management requires collection and storage of sensitive information concerning the location of nest sites, concentration areas and foraging areas. These kinds of data are essential, but at the same time pose a real threat to several species if made available to the public. Legal and legitimate uses of the falconiform resource, including bird watching, research, falconry and photography, can cause nest abandonments and failures, and illegal harvest by falconers and curiosity seekers are an increasing threat in the western United States (see Harlow 1977, 1978 and Boyce 1979). Accordingly, adequate means of protecting sensitive data collected in Arizona must be developed.

Because this concerns both state and federal agencies an interagency committee should be appointed to review the problem and identify potential solutions. Pertinent U. S. Fish and Wildlife Service, Forest Service, Bureau of Land Management, Bureau of Reclamation and Arizona Game and Fish Department district and regional personnel should review the committee's proposals and assist in selecting à workable system for data storage and retrieval. In addition, decisions regarding the dissemination of information must be reached.

Despite the form of long-range storage system selected, biologists working in the field will regularly encounter important raptor use areas. Ultimately, the protection of these areas lies in the hands of the discoverer. Each knowledgeable person in a position to encounter sensitive information should recognize a responsibility to protect and use that knowledge wisely.

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Table 1. Intraspecific relative abundance of falconiformes in major vegetation communities in winter.[a]

Plant Community	Species[b]									
	ACGE	ACST	ACCO	BUJA	BURE	AQCH	CICY	FACO	FASP	FAME
Pinyon-juniper	0	.047	.062	.015	0	0	0	0	.040	0
Chaparral	1.000	.039	.044	.113	.289	.252	.022	0	.113	.041
Desert Grassland	0	0	.013	.133	.711	.528	.235	1.000	.146	.329
Joshuatree-creosotebush	0	0	.006	.105	0	.122	.022	0	.077	.123
Paloverde-saguaro	0	.030	.006	.199	0	.041	.077	0	.065	.160
Creosotebush-bursage	0	.015	.013	.200	0	.057	.644	0	.082	.347
Mixed Broadleaf	0	.325	.113	.042	0	0	.0	0	.062	0
Cottonwood-willow	0	0	.325	.092	0	0	0	0	.290	0
Mesquite-saltcedar	0	.544	.419	.101	0	0	0	0	.125	0
Total Relative Abundance	.002	.053	.223	.260	.007	.020	.033	.007	.362	.034

a Intraspecific relative abundance calculated using the formula;

$$RA = Ni/Nj,$$

where Ni = average number individuals of species j observed per km^2 in plant community i, Nj = total average number individuals of species j observed per km^2 in all plant communities and RA = intraspecific relative abundance.

b ACGE = goshawk, ACST = sharp-shinned hawk, ACCO = Cooper's Hawk, BUJA = red-tailed hawk, BURE = ferruginous hawk, AQCH = golden eagle, CICY = harrier, FACO = merlin, FASP = kestrel, and FAME = prairie falcon.

c Total relative abundance calculated using formula;

$$RA = Nj/N,$$

where Nj = total average number individuals of species j observed per km^2 in all plant communities, N = total average number falconiformes observed per km^2 in all plant communities and RA = total intraspecific relative abundance.

Table 2. Distributional diversity of falconiformes in winter.

Species	H'[a]	HMX[b]	E[c]	No. Communities
Goshawk	0	0	--	1
Sharp-shinned Hawk	1.135	1.792	.633	6
Cooper's Hawk	1.460	2.197	.665	9
Red-tailed Hawk	2.136	2.197	.972	9
Harrier	1.411	1.792	.787	5
Ferruginous Hawk	0.601	0.693	.867	2
Golden Eagle	1.235	1.609	.768	5
Prairie Falcon	1.415	1.609	.879	5
Merlin	0	0	--	1
Kestrel	1.926	2.197	.877	9

a Calculated using Shannon and Weaver (1949) formula;

$$H' = \sum_{i=1}^{s} p_i \ln p_i,$$

where p_i = intraspecific relative abundance of species i in a given plant community, s = the number of plant communities occupied and H' = distributional diversity.

b HMX = lns, where s = number plant communities occupied by the species. Maximum possible diversity given s plant communities.

c E (equitability) = H'/HMX.

Table 3. Intraspecific relative abundance of falconiformes in major vegetation communities in summer.[a]

Plant Community	Species[b]									
	ACGE	ACST	ACCO	BUJA	BUAL	BUAN	PAUN	AQCH	FASP	FAME
Montane Conifer	1.000	1.000	.103	.052	.109	0	0	0	.047	0
Pinyon-juniper	0	0	.053	.005	0	0	0	0	.039	0
Chaparral	0	0	.091	.220	.136	0	0	.309	.139	.309
Desert Grassland	0	0	0	.113	.054	0	0	.395	.069	.385
Joshuatree-creosotebush	0	0	0	.105	0	0	0	.185	.089	.034
Paloverde-saguaro	0	0	.003	.051	.01	0	1.000	.037	.050	.082
Creosotebush-bursage	0	0	0	.030	0	0	0	.074	.157	.200
Mixed Broadleaf	0	0	.478	.106	.382	.189	0	0	.117	0
Cottonwood-willow	0	0	.267	.248	.318	.811	0	0	.272	0
Mesquite-saltcedar	0	0	.005	.070	0	0	0	0	.021	0
Total Relative Abundance	.028	.004	.217	.226	.015	.047	<.001	.017	.388	.056

a Intraspecific relative abundance calculated using the formula;

$$RA = Ni/Nj,$$

where Ni = average number individuals of species j observed per km^2 in plant community i, Nj = total average number individuals of species j observed per km^2 in all plant communities and RA = intraspecific relative abundance.

b ACGE = goshawk, ACST = sharp-shinned hawk, ACCO = Cooper's Hawk, BUJA = red-tailed hawk, BUAL = zone-tailed hawk, BUAN = black hawk, PAUN = Harris' Hawk, AQCH = golden eagle, FASP = kestrel, and FAME = prairie falcon.

c Total relative abundance calculated using formula;

$$RA = Nj/N,$$

where Nj = total average number individuals of species j observed per km^2 in all plant communities, N = total number falconiformes observed per km^2 in all plant communities and RA = total intraspecific relative abundance.

Table 4. Distributional diversity of falconiformes in summer.

Species	H'[a]	HMX[b]	E[c]	No. Communities
Goshawk	0	0	--	1
Sharp-shinned Hawk	0	0	--	1
Cooper's Hawk	1.462	1.946	.773	7
Red-tailed Hawk	2.023	2.303	.878	10
Black Hawk	0.485	0.693	.670	2
Zone-tailed Hawk	1.402	1.609	.871	6
Harris' Hawk	0	0	--	1
Golden Eagle	1.357	1.609	.843	5
Prairie Falcon	1.369	1.609	.851	5
Kestrel	2.071	2.303	.899	10

a Calculated using Shannon and Weaver (1949) formula;

$$H' = \sum_{i=1}^{s} p_i \ln p_i,$$

where p_i = intraspecific relative abundance of species i in a given plant community, s = the number of plant communities occupied and H' = distributional diversity.

b HMX = lns, where s = number plant communities occupied by the species. Maximum possible diversity given s plant communities.

c E (equitability) = H/HMX.

Table 5. Interspecific relative abundance of falconiformes in major vegetation communities in winter.[a]

Species	Plant Community[b]								
	PJ	CH	DG	JC	PS	CB	MB	CW	MS
Goshawk	0	.013	0	0	0	0	0	0	0
Sharp-shinned Hawk	.049	.026	0	0	.045	.012	.138	0	.230
Cooper's Hawk	.350	.158	.013	.033	.045	.054	.573	.414	.333
Red-tailed Hawk	.351	.273	.259	.394	.231	.275	.098	.172	.231
Ferruginous Hawk	0	.018	.034	0	0	0	0	0	0
Golden Eagle	0	.044	.069	.033	.016	.012	0	0	0
Harrier	0	.006	.046	.009	.045	.127	0	0	.0
Merlin	0	0	.046	0	0	0	0	0	0
Kestrel	.249	.449	.435	.471	.587	.389	.191	.414	.205
Prairie Falcon	0	.013	.098	.059	.032	.131	0	0	0
Total Relative Abundance	.055	.087	.116	.056	.039	.073	.227	.243	.105

a Interspecific relative abundance calculated using the formula;

$$RA = N_{ij}/N,$$

where Nij = average number individuals of species j observed per km^2 in plant community i, N = total average number falconiformes observed per km^2 in plant community i and RA = interspecific relative abundance.

b PJ = pinyon-juniper, CH = chaparral, DG = desert grassland, JC = joshuatree-creosote, PS = paloverde-saguaro, CB = creosotebush-bursage, MB = mixed broadleaf, CW = cottonwood-willow and MS = mesquite-saltcedar.

c Total relative abundance calculated using formula;

$$RA = N_i/N,$$

Where Ni = total average number falconiformes observed per km^2 in plant community i, N = total average number falconiformes observed per km^2 in all plant communities and RA = total interspecific relative abundance.

Table 6. Winter plant community falconiform diversity.

Plant Community	H'[a]	HMX[b]	E[c]	No. Spp.
Pinyon-juniper	1.233	1.390	.885	4
Chaparral	1.591	2.197	.724	9
Desert Grassland	1.607	2.079	.773	8
Joshuatree-creosotebush	1.156	1.792	.645	6
Paloverde-saguaro	1.246	1.946	.640	7
Creosotebush-bursage	1.514	1.946	.778	7
Mixed Broadleaf	1.136	1.390	.817	4
Cottonwood-willow	1.033	1.099	.940	3
Mesquite-saltcedar	1.489	1.609	.925	5

[a] Calculated using Shannon and Weaver (1949) formula;

$$H' = \sum_{i=1}^{s} p_i \ln p_i,$$

where p_i = interspecific relative abundance of species i in a given plant community, s = number species observed in plant community and H' = falconiform diversity.

[b] HMX = lns, where s = number species observed in plant community. Maximum possible diversity given s species.

[c] E (equitability) = H/HMX.

Table 7. Interspecific relative abundance of falconiformes in major vegetation communities in summer.[a]

Species	Plant Community[b]									
	MC	PJ	CH	DG	JC	PS	CB	MB	CW	MS
Goshawk	.282	0	0	0	0	0	0	0	0	0
Sharp-shinned Hawk	.045	0	0	0	0	0	0	0	0	0
Cooper's Hawk	.308	.498	.272	0	0	.025	0	.578	.241	.425
Red-tailed Hawk	.091	.028	.232	.286	.319	.290	.306	.076	.157	.344
Zone-tailed Hawk	.091	0	.025	.065	0	.01	0	.131	.097	0
Black Hawk	0	0	0	0	0	0	0	.033	.126	0
Harris' Hawk	0	0	0	0	0	.004	0	0	0	0
Golden Eagle	0	0	.032	.059	.033	.013	.045	0	0	0
Kestrel	.182	.473	.322	.382	.595	.626	.470	.183	.379	.231
Prairie Falcon	0	0	.116	.208	.051	.042	.179	0	0	0
Total Relative Abundance	.103	.033	.072	.060	.103	.032	.018	.256	.286	.036

a Interspecific relative abundance calculated using the formula;

$$RA = Nij/N,$$

where Nij = average number individuals of species j observed per km^2 in plant community i, N = total average number falconiformes observed per km^2 in plant community i and RA = interspecific relative abundance.

b MC = montane conifer, PJ = pinyon-juniper, CH = chaparral, DG = desert grassland, JC = joshuatree-creosote, PS = paloverde-saguaro, CB = creosotebush-bursage, MB = mixed broadleaf, CW = cottonwood-willow and MS = mesquite-saltcedar.

c Total relative abundance calculated using formula;

$$RA = Ni/N,$$

where Ni = total average number falconiformes observed per km^2 in plant community i, N = total average number falconiformes observed per km^2 in all plant communities and RA = total interspecific relative abundance.

Table 8. Summer plant community falconiform diversity.

Plant Community	H'[a]	HMX[b]	E[c]	No. Spp.
Montane Conifer	1.606	1.792	.896	6
Pinyon-juniper	0.801	1.099	.729	3
Chaparral	1.212	1.792	.676	6
Desert Grassland	1.398	1.609	.869	5
Joshuatree-creosotebush	0.938	1.386	.677	4
Paloverde-saguaro	0.956	1.792	.533	7
Creosotebush-bursage	1.165	1.386	.841	4
Mixed Broadleaf	1.202	1.609	.747	5
Cottonwood-willow	1.485	1.609	.923	5
Mesquite-saltcedar	1.069	1.099	.974	3

[a] Calculated using Shannon and Weaver (1949) formula;

$$H' = \sum_{i=1}^{s} p_i \ln p_i,$$

where p_i = interspecific relative abundance of species i in a given plant community, s = number of species observed in plant community and H' = falconiform diversity.

[b] HMX = lns, where s = number species observed in plant community.

[c] E (equitability) = H/HMX.

Table 9. Mean vegetative characteristics at perch sites of selected falconiformes.[a]

Species	(N)	Maximum Vegetation Height (m)[c]	Canopy Area	Canopy Volume Index (m)
Sharp-shinned Hawk	(11)	4.572 ± 2.150	0.135 ± 0.045	0.584 ± 0.278
Cooper's Hawk	(27)	3.658 ± 3.392	0.210 ± 0.084	0.365 ± 0.316
Red-tailed Hawk	(39)	1.500 ± 2.370	0.132 ± 0.218	0.198 ± 0.531
Ferruginous Hawk	(8)	0.340 ± 0.710	0.316 ± 0.160	0.107 ± 0.100
Golden Eagle	(10)	1.065 ± 0.643	0.203 ± 0.057	0.198 ± 0.070
Kestrel	(53)	1.000 ± 2.750	0.129 ± 0.226	0.129 ± 0.640
Prairie Falcon	(16)	0.941 ± 1.125	0.217 ± 0.157	0.203 ± 0.231
Harrier[b]	(21)	0.827 ± 0.470	0.216 ± 0.126	0.149 ± 0.104
Mean (Total)	(186)	1.456 ± 3.104	0.129 ± 0.866	0.187 ± 0.635

[a] See text, Methods and Data Treatment, for description of vegetation characters.

[b] Harriers hunt from flight and were seldom observed perching. Vegetation was therefore measured under flight lines rather than around perches for this species.

[c] t' tests of mean vegetation height indicated significant differences ($p < 0.05$) existed between the following species pairs: (1) sharp-shinned hawk and red-tailed hawk, ferruginous hawk, golden eagle, kestrel, prairie falcon and harrier; and (2) Cooper's Hawk and ferruginous hawk, golden eagle, kestrel, prairie falcon and harrier.

Table 10. Characteristics of vegetation in selected arboreal falconiform nest stands.[a]

Species / Plant Community	n	Tree Density (No./ha)	Tree Size (m^3)[c]	Canopy Area	Canopy Width (m)	Canopy Volume Index (m)
		Mean ± 1SD/Range[b]				
Cooper's Hawk						
Pinyon-juniper	4	138.0 ± 41.3	0.8 ± 0.4	0.10 ± 0.05	11.2 ± 0.3	1.13 ± 0.65
		81.3 - 174.8	0.5 - 1.3	0.04 - 0.20	10.9 - 11.5	0.44 - 1.96
Mixed broadleaf	8	397.8 ± 326.6	1.3 ± 0.8	0.19 ± 0.08	9.2 ± 1.8	1.84 ± 1.12
		67.3 - 1165.5	0.1 - 2.5	0.08 - 0.30	7.3 - 11.5	0.58 - 3.45
Cottonwood-willow	10	553.9 ± 414.9	1.5 ± 1.2	0.20 ± 0.14	15.9 ± 5.3	3.10 ± 2.37
		158.2 - 1555.2	0.1 - 5.5	0.04 - 0.48	10.5 - 29.3	0.57 - 7.38
		403.5 ± 363.9	1.2 ± 1.3	0.18 ± 0.12	12.6 ± 4.8	2.28 ± 1.88
Population Mean/Range	22	81.3 - 1555.2	0.1 - 5.5	0.04 - 0.48	7.3 - 29.3	0.44 - 7.38
Red-tailed Hawk						
Joshuatree-creosotebush	13	9.2 ± 7.1	0.5 ± 0.2	0.03 ± 0.03	5.8 ± 2.1	0.17 ± 0.08
		1.0 - 20.2	0.2 - 0.8	0.01 - 0.09	3.9 - 7.9	0.04 - 0.71
Paloverde-saguaro	13	28.6 ± 32.8	0.4 ± 0.4	0.02 ± 0.01	2.0 ± 0.9	0.03 ± 0.03
		1.0 - 121.1	0.1 - 1.5	0 - 0.04	0 - 7.9	0 - 0.32
Cottonwood-willow	8	60.8 ± 83.2	8.7 ± 11.7	0.06 ± 0.06	15.8 ± 1.9	0.85 ± 0.81
		1.0 - 194.4	0.5 - 29.1	0 - 0.16	14.9 ± 16.7	0 - 1.58
		28.7 ± 47.8	2.2 ± 6.2	0.03 ± 0.04	6.1 ± 6.6	0.31 ± 0.59
Population Mean/Range	34	1.0 - 194.4	0.1 - 29.1	0 - 0.16	0 - 16.7	0 - 1.58
Zone-tailed Hawk						
Cottonwood-willow	9	216.9 ± 123.3	5.5 ± 4.6	0.12 ± 0.04	16.0 ± 3.4	1.87 ± 0.71
		53.8 - 431.0	0.3 - 14.5	0.05 - 0.18	10.3 - 20.7	0.76 - 3.26
		216.9 ± 123.3	5.5 ± 4.6	0.12 ± 0.04	16.0 ± 3.4	1.87 ± 0.71
Population Mean/Range	9	53.8 - 431.0	0.3 - 14.5	0.05 - 0.18	10.3 - 20.7	0.76 - 3.26
Black Hawk						
Cottonwood-willow	8	221.7 ± 96.9	2.8 ± 1.2	0.12 ± 0.04	17.0 ± 3.6	1.97 ± 0.84
		171.2 - 458.5	0.5 - 4.5	0.05 - 0.14	11.9 - 22.9	0.83 - 3.11
		221.7 ± 96.9	2.8 ± 1.2	0.12 ± 0.04	17.0 ± 3.6	1.97 ± 0.84
Population Mean/Range	8	171.2 - 458.5	0.5 - 4.5	0.05 - 0.14	11.9 - 22.9	0.83 - 3.11

a Only species/plant communities where 4 or more stands were measured are included. Stand defined as area within 30 m radius of nest tree. For description of vegetation characters see text, Methods and Data Treatment.

b t' test indicated population means significantly different ($p < 0.05$) for the following species pairs: (1) tree density, Cooper's hawk - red-tailed hawk, red-tailed hawk - black hawk and zone-tailed hawk; (2) tree size, Cooper's hawk - zone-tailed hawk and black hawk; (3) canopy width, Cooper's hawk - red-tailed hawk and black hawk, red-tailed hawk - zone-tailed hawk and black hawk; (4) canopy volume, Cooper's hawk - red-tailed hawk, red-tailed hawk - zone-tailed hawk and black hawk.

c For comparison, a tree 25 m tall with a dbh of 30cm (.3m) would give a tree size measurement of 1.69m^3, a 29 m tree with a dbh of 68 cm would be 10.53 m^3 and a 10 m tree with a dbh of 15 cm would be .17m^3

Table 11. Estimated nest density for selected falconiformes by plant community.[a]

Species Plant Community	Nest Density Maximum No./km^2	 Minimum No./km^2	 Mean/km^2
Cooper's Hawk			
Montane Conifer	0.201	0.051	0.125
Pinyon-juniper	0.174	0.032	0.100
Mixed broadleaf	3.543	0.102	1.820
Cottonwood-willow	2.001	0.092	1.050
Red-tailed Hawk			
Pinyon-juniper	0.092	0.010	0.051
Joshuatree-creosotebush	0.136	0.052	0.094
Paloverde-saguaro	0.140	0.051	0.100
Zone-tailed Hawk			
Cottonwood-willow	0.003	0.001	0.002
Black Hawk[b]			
Cottonwood-willow	2.101	0.501	1.301

a Calculated for upland communities using formula;

$$1/ \quad r^2,$$

where r = 1/2 distance in km between active nests and D = estimated number nests per km^2. Assumes circular territories which is probably inaccurate in many cases. For riparian habitats nest density was estimated as 1/2 the distance between adjacent nests multiplied by the average width of the riparian corridor. Thus, if nests averaged 1 km apart and the corridor 500 m wide, nest density would be 1.0/km^2.

b Calculated only for Burro Creek upstream from Yavapai County line.

Table 12. Types and dimensions of nest substrates used by selected falconiformes.[a]

Species Substrate[b]	n	Mean Height ± 1SD (m) Nest	Substrate	Mean ± 1SD DBH (cm)	Surface Area (m^2)[c]	Type of Nest (%) Platform	Cavity
Goshawk							
Ponderosa Pine	2	15.2 ± 1.3	20.8 ± 7.8	91.4 ± 1.4	--	100.0	0
Sharp-shinned Hawk							
Ponderosa Pine	1	4.9	6.7	22.9	--	100.0	0
White Fir[d]	1	4.6	5.8	17.8	--	100.0	0
Cooper's Hawk							
Pinyon Pine	5	5.1 ± 1.2	7.0 ± 2.1	30.0 ± 1.9	--	100.0	0
Ponderosa Pine	4	10.5 ± 6.3	16.3 ± 8.0	49.0 ± 11.7	--	100.0	0
Cottonwood	30	13.8 ± 4.5	19.5 ± 2.7	89.2 ± 21.0	--	100.0	0
Arizona Alder	4	10.6 ± 0.0	14.0 ± 1.7	12.5 ± 1.7	--	100.0	0
Emory Oak	4	8.7 ± 0.6	12.5 ± 1.7	41.4 ± 2.2	--	100.0	0
Gambel Oak	6	4.5 ± 0.7	6.4 ± 2.3	11.0 ± 1.4	--	100.0	0
N-1 Hackberry	5	7.2 ± 2.2	10.6 ± 2.4	45.5 ± 12.1	--	100.0	0
Sycamore	8	9.4 ± 8.2	17.2 ± 3.7	44.5 ± 2.3	--	100.0	0
Velvet Ash	6	10.4 ± 2.0	13.8 ± 1.6	5.3 ± 1.0	--	100.0	0
Athel	1	16.7	19.8	5.7	--	100.0	0
Red-tailed Hawk							
Pinyon Pine	6	7.3 ± 0.4	8.1 ± 0.2	50.0 ± 2.3	--	100.0	0
Ponderosa Pine	3	18.2 ± 3.4	22.8 ± 5.1	71.1 ± 5.4	--	100.0	0
Cottonwood	21	16.4 ± 4.7	18.6 ± 5.7	110.6 ± 55.2	--	100.0	0
Emory Oak	1	19.8	15.2	45.7	--	100.0	0
N-1 Hackberry	1	6.7	7.6	38.6	--	100.0	0
Velvet Ash	3	10.2 ± 1.1	13.8 ± 2.4	91.6 ± 25.7	--	100.0	0
Mesquite	1	5.3	5.5	53.3	--	100.0	0
Athel	2	12.3 ± 1.0	17.1 ± 1.2	81.3 ± 2.1	--	100.0	0
Paloverde	1	6.8	7.3	42.2	--	100.0	0
Saguaro	56	3.6 ± 1.2	5.9 ± 1.4	56.3 ± 1.4	--	100.0	0
Joshuatree	23	3.7 ± 0.3	5.3 ± 1.2	35.4 ± 8.6	--	100.0	0
Power Pole	8	13.1 ± 10.9	14.7 ± 10.4	--	--	100.0	0
Cliff	41	12.2 ± 8.1	17.1 ± 5.8	--	477.8 ± 63.3	100.0	0
Zone-tailed Hawk							
Ponderosa Pine	2	19.8 ± 0.3	22.9 ± 1.2	63.5 ± 0.4	--	100.0	0
Cottonwood	16	13.7 ± 3.5	17.3 ± 2.2	74.1 ± 7.1	--	100.0	0
Emory Oak	3	18.3 ± 3.6	15.8 ± 2.6	53.8 ± 9.2	--	100.0	0
Sycamore	7	15.2 ± 5.3	15.6 ± 5.7	76.2 ± 9.6	--	100.0	0
Black Hawk							
Cottonwood	19	15.3 ± 1.2	20.2 ± 5.1	81.9 ± 15.7	--	100.0	0
Arizona Alder	1	16.2	18.3	50.8	--	100.0	0
Sycamore	3	15.7 ± 0.6	18.3 ± 4.3	82.6 ± 5.4	--	100.0	0
Goodding Willow	1	14.1	16.8	73.7	--	100.0	0
Golden Eagle							
Cliff	22	13.5 ± 6.2	18.6 ± 4.8	--	6373.0 ± 1021.2	100.0	0
Prairie Falcon							
Cliff	44	14.4 ± 9.1	19.8 ± 3.5	--	7887.8 ± 8736.9	0	100.0

a For description of measurements presented see text, Methods and Data Treatment.
b For scientific names of trees see text, Study Area.
c For comparison, a cliff 30 m tall by 120m long would have an estimated surface area of 3,600 m^2, a 25 m tall cliff with a length of 60 m would have a surface area of 1,500 m^2 and a 60 m tall cliff, 450 m long, would have a surface area of 27,000 m^2.
d Inactive nest in Hualapai Mountains, on same territory as nest in ponderosa pine.

Table 13. Productivity statistics for selected falconiformes.

Species	Number Occupied Territories		Mean ± 1SD per Occupied Territory/per Nest with Eggs[a]					Probability of Survivorship[a,b]		
	Under Observation	No Eggs Laid (%)	Clutch Size	% Hatched	Brood Size	% Fledged	No. Fledged	Egg	Nestling	Nest
Cooper's Hawk	54	8(14.8)	2.79 ± 1.37	--	2.47 ± 1.73	--	2.23 ± 1.4	--	--	0.77
			3.33 ± 0.62	88.50	2.94 ± 1.03	90.28	2.65 ± 1.16	0.83	0.96	0.89
Red-tailed Hawk	110	2(1.8)	2.71 ± 1.21	--	2.30 ± 1.81	--	2.21 ± 1.83	--	--	0.92
			2.79 ± 1.03	84.91	2.36 ± 1.60	96.08	2.26 ± 1.64	0.91	0.94	0.93
Zone-tailed Hawk	22	0(0)	2.10 ± 0.70	--	1.90 ± 0.71	--	1.85 ± 0.96	--	--	0.95
			2.10 ± 0.70	90.47	1.90 ± 0.71	97.36	1.85 ± 0.96	0.94	0.91	0.95
Black Hawk	22	1(4.5)	1.92 ± 0.21	--	1.54 ± 0.95	--	1.30 ± 0.99	--	--	0.88
			1.93 ± 0.18	80.21	1.55 ± 0.92	84.42	1.31 ± 0.82	0.91	0.96	0.93
Golden Eagle	20	3(15.0)	1.55 ± 0.88	--	1.30 ± 0.80	--	1.25 ± 0.79	--	--	0.80
			1.88 ± 0.38	83.87	1.58 ± 0.72	96.15	1.52 ± 0.66	0.88	0.93	0.91
Prairie Falcon	30	4(13.3)	3.32 ± 1.51	--	2.97 ± 1.56	--	2.80 ± 1.47	--	--	0.85
			3.85 ± 1.48	89.46	3.44 ± 1.42	94.28	3.24 ± 1.37	0.93	0.94	0.94

a Upper row for each species includes statistics calculated using total number of occupied territories. Lower row calculated using only territories on which eggs were set. Former statistics more accurately portray productivity of the population.

b Calculated using Mayfield 40-percent Method (Johnson 1979).

Table 14. Observed prey of falconiformes.

Species Prey	Frequency of Occurrence No.	 % Total	Occurrence by Weight[a] Biomass(g)	 % Total Biomass
Cooper's Hawk				
Mammals	117	20.6	32,432	45.4
Black-tailed jackrabbit	1	0.2	700	1.0
Cottontail rabbit	80	14.2	28,000	39.2
Harris' Antelope Grd. Squirrel	18	3.2	1,890	2.6
Cliff chipmunk	5	0.8	342	0.5
Woodrat	12	2.1	1,800	2.5
Muskrat	1	0.1	400	0.6
Birds	419	73.9	38,299	53.6
Gambel's Quail	43	7.0	12,320	17.2
Mourning dove	64	11.0	8,480	11.9
White-winged dove	10	1.8	1,426	2.0
Yellow-billed cucco	1	0.2	121	0.2
Roadrunner	5	0.9	1,270	1.8
Common nighthawk	1	0.2	106	0.1
Common flicker	16	2.8	2,099	0.3
Gila Woodpecker	1	0.2	137	0.2
Ladder-backed woodpecker	4	0.7	205	0.3
Yellow-bellied sapsucker	5	0.9	238	0.3
Western kingbird	15	1.4	630	0.9
Cassin's Kingbird	5	0.9	210	0.3
Ash-throated flycatcher	6	1.1	330	0.5
Vermillion flycatcher	4	0.7	70	0.1
Western wood pewee	6	1.1	77	0.1
Horned lark	2	0.4	52	+
Scrub jay	25	4.4	1,808	3.0
Mockingbird	3	0.5	117	0.2
Hermit thrush	1	0.2	25	+
Robin	36	6.1	2,930	4.1
Cedar waxwing	1	0.2	34	+
Starling	5	0.9	395	0.5
Bell's Vireo	2	0.4	22	+
Solitary vireo	2	0.4	22	+
Yellow-rumped warbler	2	0.4	20	+
Yellow warbler	2	0.4	20	+
Townsend's Warbler	1	0.2	9	
Northern oriole	4	0.7	152	0.2
Unid. oriole	8	1.0	304	0.4
Great-tailed grackle	4	0.7	580	0.8
Brown-headed cowbird	14	2.5	560	0.8
Summer tanager	4	0.7	164	0.2
Cardinal	3	0.5	105	0.1
Rufous-sided towhee	12	2.1	468	0.7

Table 14. Continued.

Species Prey	Frequency of Occurrence No.	 % Total	Occurrence by Weight[a] Biomass(g)	 % Total Biomass
Cooper's Hawk--Birds (Cont.)				
Unid. towhee	5	0.9	195	0.3
Black-headed grosbeak	2	0.4	85	0.1
House finch	21	3.7	420	0.6
Black-throated sparrow	6	1.0	127	0.2
Lark sparrow	1	0.2	19	+
White-crowned sparrow	18	3.2	432	0.6
Unid. medium bird	30	5.3	1,230	1.7
Unid. small bird	19	3.4	285	0.4
Reptiles	18	3.2	694	1.0
Collared lizard	6	1.0	330	0.5
Desert spiny lizard	3	0.5	213	0.3
Tree lizard	1	0.5	6	+
Unid. whiptail lizard	1	0.2	25	+
Gopher snake	3	0.5	40	0.1
Black-necked garter snake	4	0.7	80	0.1
Invertebrates	13	2.3	16	+
Scorpions	3	0.5	11	+
Other	10	1.8	5	+
Total	567		71,441	x̄ prey weight = 126.0g
Red-tailed Hawk				
Mammals	190	58.3	67,346	79.5
Black-tailed jackrabbit	23	7.1	20,700	24.4
Cottontail rabbit	73	22.4	36,500	43.1
Cliff chipmunk	2	0.6	137	0.1
Harris' Antelope Grd. Squirrel	33	10.1	3,465	4.1
Rock squirrel	7	2.1	1,820	2.1
Round-tailed ground squirrel	26	8.0	2,990	3.5
Abert's Squirrel	1	0.3	285	0.3
Valley pocket gopher	1	0.3	185	0.2
Kangaroo rat	6	1.8	300	0.4
Deer mouse	2	0.6	42	+
Cotton rat	1	0.3	192	0.2
Woodrat	14	4.3	150	0.2
Ringtail	1	0.3	580	0.7

Table 14. Continued

Species Prey	Frequency of Occurrence No.	 % Total	Occurrence by Weight[a] Biomass(g)	 % Total Biomass
Red-tailed Hawk (Cont.)				
Birds	45	13.8	9,717	11.5
Gambel's Quail	28	8.9	8,022	9.5
Mourning dove	6	1.8	795	0.9
Poorwill	1	0.3	110	0.1
Common flicker	1	0.3	131	0.1
Ladder-backed woodpecker	1	0.3	51	+
Scrub jay	2	0.6	144	0.2
Starling	1	0.3	79	0.1
Great-tailed grackel	1	0.3	165	0.2
Bendire's Thrasher	4	1.2	220	0.3
Reptiles	84	25.7	7,612	9.0
Chuckwalla	2	0.6	244	0.3
Zebra-tailed lizard	1	0.3	15	+
Desert spiny lizard	44	13.5	3,124	3.8
Desert horned lizard	1	0.3	22	+
Unid. whiptail lizard	1	0.3	25	+
Coachwhip snake	3	0.9	410	+
Patch-nosed snake	2	0.6	58	0.1
Glossy snake	2	0.6	48	+
Gopher snake	7	2.2	2,098	2.6
California Kingsnake	9	2.8	495	0.6
Black-necked garter snake	1	0.3	10	+
Long-nosed snake	7	2.1	623	0.8
Sidewinder	4	1.2	440	0.5
Invertebrates	7	2.2	0.4	+
Unid. Coleopteran	4	1.2	1.8	+
Unid. Centipede	3	0.9		
Total	326		84,677.2	x̄ prey weight = 259.7g
Zone-tailed Hawk				
Mammals	28	31.8	3,577	41.2
Cottontail rabbit	2	2.3	600	6.9
Cliff chipmunk	8	9.1	547	6.3
Harris' Antelope Grd. Squirrel	11	12.5	1,155	13.3
Rock squirrel	3	3.4	780	9.0
Round-tailed ground squirrel	3	3.4	345	4.0
Woodrat	1	1.1	150	1.7

Table 14. Continued.

Species Prey	Frequency of Occurrence No.	% Total	Occurrence by Weight[a] Biomass(g)	% Total Biomass
Zone-tailed Hawk (Cont.)				
Birds	13	14.8	3,228	37.2
Gambel's Quail	11	12.5	3,152	36.3
Northern oriole	2	2.3	76	0.9
Reptiles	38	43.2	1,746	20.1
Zebra-tailed lizard	1	1.1	15	0.2
Collared lizard	24	27.3	1,320	15.2
Desert spiny lizard	2	2.3	142	1.6
Desert horned lizard	5	5.7	110	1.3
Unid. whiptail lizard	4	4.6	100	1.2
Gilbert's Skink	1	1.1	30	0.3
Patch-nosed snake	1	1.1	29	0.3
Amphibians	7	8.0	110	1.3
Canyon tree frog	3	3.4	30	0.3
Leopard frog	4	4.6	80	0.9
Invertebrates	2	2.3	22	0.3
Centipede	2	2.3	22	0.3
Total	88		8,683	x̄ prey weight = 98.7g
Black Hawk				
Mammals	2	1.3	272	5.5
Rock squirrel	1	0.6	260	5.3
Unid. bat	1	0.6	12	0.2
Birds	3	1.9	95	1.9
Cassin's Kingbird	2	1.3	84	1.7
Unid. Vireo	1	0.6	11	0.2
Reptiles	34	21.5	676	13.7
Chuckwalla	1	0.6	122	2.5
Tree lizard	5	3.2	30	0.6
Long-tailed brush lizard	4	2.5	24	0.5
Patch-nosed snake	1	0.6	29	0.6
Black-necked garter snake	22	13.9	440	8.9
Yellow mud turtle	1	0.6	31	0.6
Amphibians	51	32.3	867	17.6
Leopard frog	51	32.3	867	17.6

Table 14. Continued.

Species Prey	Frequency of Occurrence No.	 % Total	Occurrence by Weight[a] Biomass(g)	 % Total Biomass
Black Hawk (Cont.)				
Fish	55	34.8	2,905	59.0
Roundtail chub	7	4.4	385	7.8
Gila Mountain Sucker	8	5.1	480	9.7
Gila Sucker	32	20.3	1,600	32.5
Unid. sucker	8	5.1	440	8.9
Invertebrates	13	8.2	110	2.2
Cicada	1	0.6	2	+
Hornworm	4	2.5	20	0.4
Centipede	8	5.1	88	1.7
Total	158		4,925	x̄ prey weight = 31.2g
Golden Eagle				
Mammals	86	97.0	142,500	99.4
Black-tailed jackrabbit	52	58.4	120,400	84.0
Cottontail rabbit	34	38.2	22,100	15.4
Birds	1	1.1	287	0.2
Gambel's Quail	1	1.1	287	0.2
Reptiles	2	2.2	596	0.4
Gopher snake	2	2.2	596	0.4
Total	89		143,383	x̄ prey weight = 1,611.0g
American Kestrel				
Mammals	24	19.7	584	32.4
Harris' Antelope Grd. Squirrel	1	0.8	105	5.9
Deer mouse	19	15.5	399	22.1
House mouse	4	3.3	80	4.4
Birds	29	23.8	634	35.1
Horned lark	6	4.9	156	8.6
House finch	1	0.8	20	1.1
House sparrow	1	0.8	20	1.1
Black-throated sparrow	3	2.5	64	3.5
Unid. small passerine	14	11.5	210	11.6
Unid. medium passerine	4	3.3	164	9.1

Table 14. Continued.

Species Prey	Frequency of Occurrence No.	 % Total	Occurrence by Weight[a] Biomass(g)	 % Total Biomass
American Kestrel (Cont.)				
Reptiles	21	17.2	504	27.9
Desert spiny lizard	3	2.5	213	11.8
Side-blotched lizard	12	9.8	180	10.0
Unid. lizard	4	3.3	80	4.4
Glossy snake	1	0.8	24	1.3
Ground snake	1	0.8	7	0.4
Invertebrates	48	39.3	83	4.6
Unid. beetle	13	10.7	26	1.4
Unid. grasshopper	13	10.7	26	1.4
Cicada	14	11.5	28	1.6
Scorpion	3	2.5	3	0.2
Total	122		1,805	$\bar{x}$ prey weight = 14.8 g
Prairie Falcon			10,805	52.2
Mammals	82	54.6	2,400	11.6
Cottontail rabbit	8	5.3	2,205	10.7
Harris' Antelope Grd. Squirrel	21	14.0	5,750	27.8
Round-tail ground squirrel	50	33.3	450	2.2
Woodrat	3	2.0		
			9,820	47.4
Birds	59	44.0	4,584	22.1
Gambel's Quail	16	10.7	3,578	17.3
Mourning dove	27	18.0	78	0.4
Horned lark	3	2.0	1,580	7.6
Starling	20	13.3		
			71	0.3
Reptiles	1	0.7	71	0.3
Desert spiny lizard	1	0.7		
Total	150		20,696	$\bar{x}$ prey weight = 138.0g

a Scientific names and average weight of prey species are given in Appendix I.

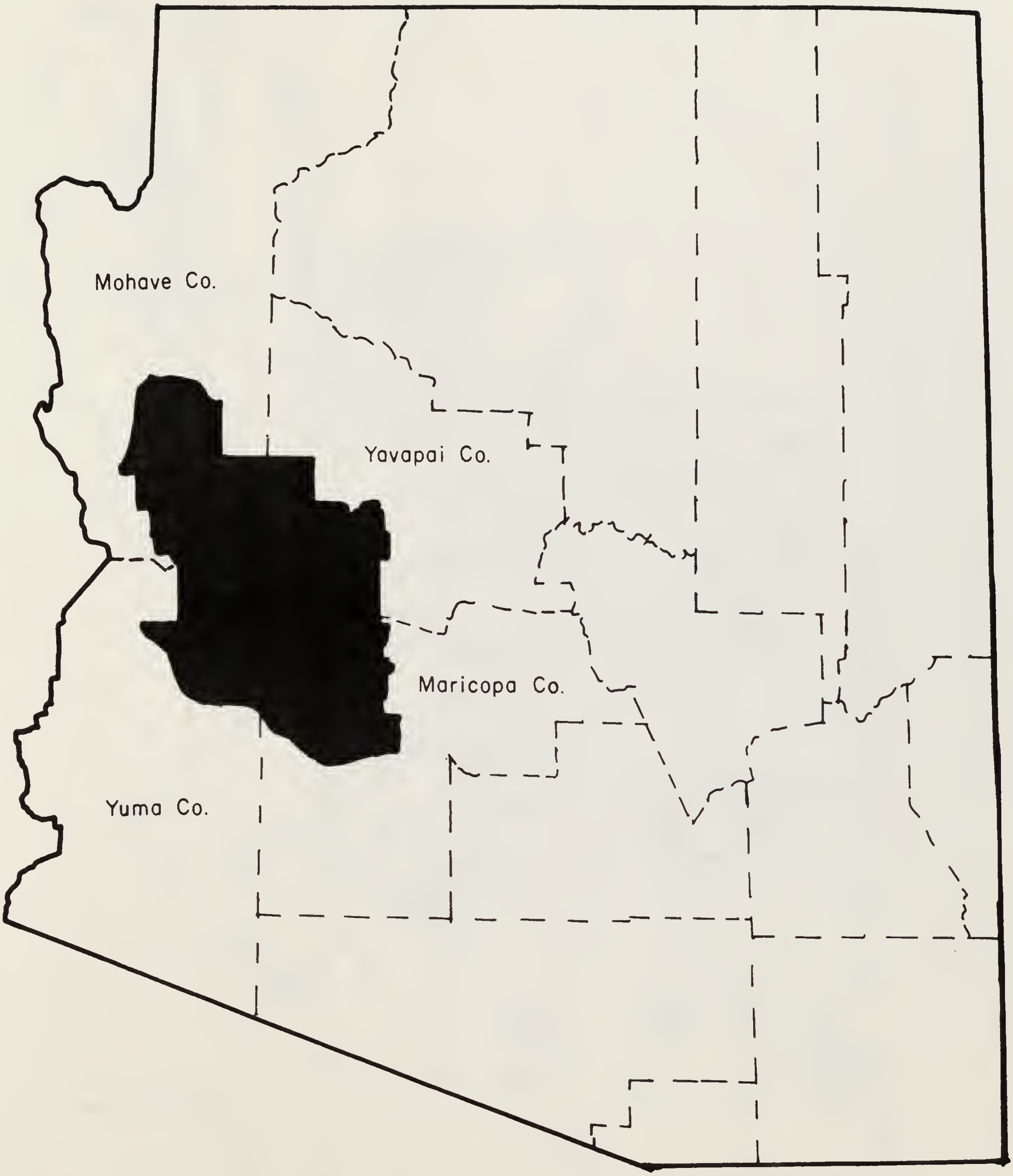


Fig. 1. Map of Arizona showing location of the study area.

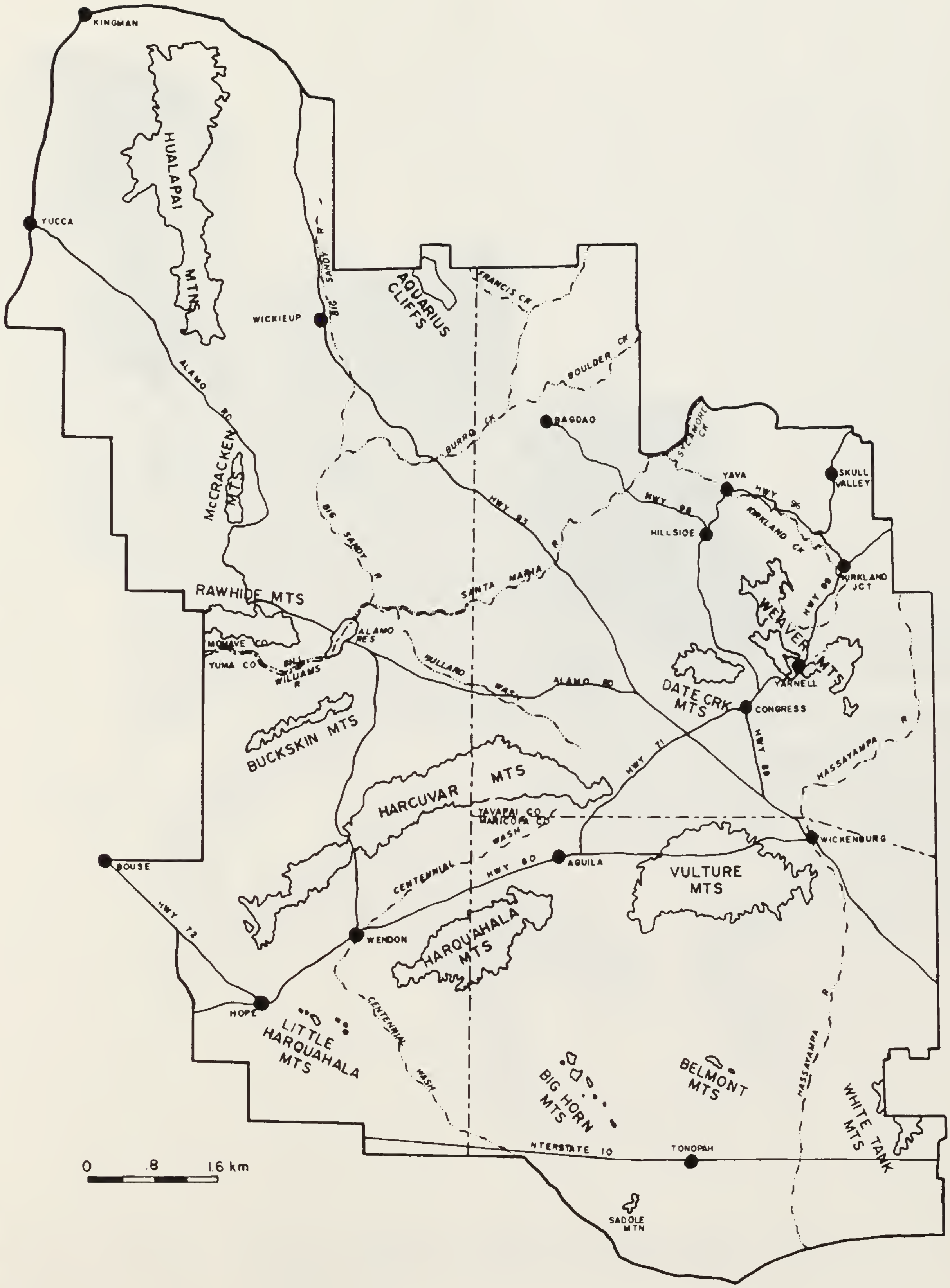


Fig. 2. Map of study area showing important physiographic and political features for reference.

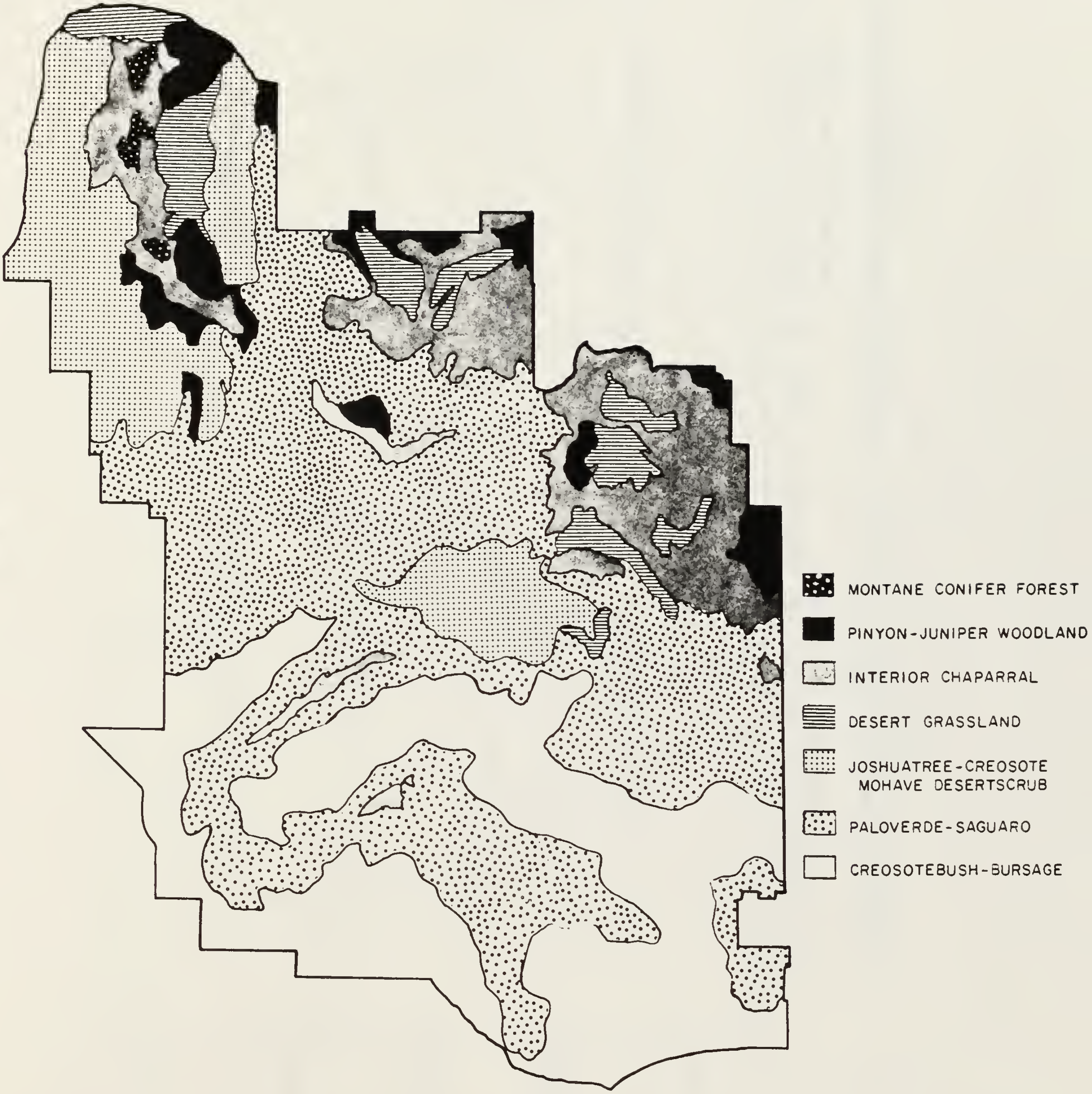


Fig. 3. Map of study area showing distributions of major upland plant communities.

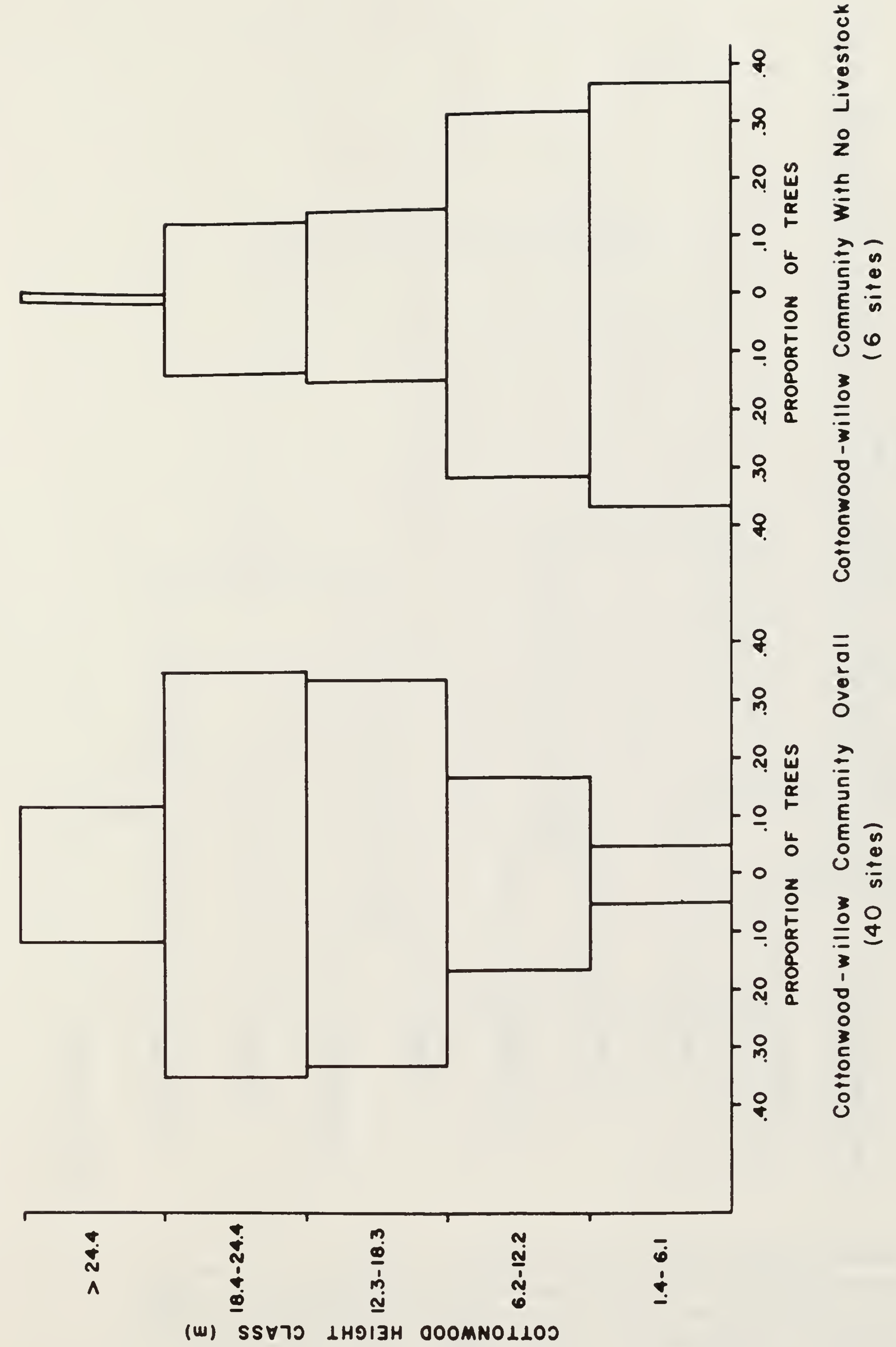


Fig. 4. Comparison of cottonwood (Populus fremontii) population size structure in heavy (left) and lightly (right) grazed riparian areas on the study area.

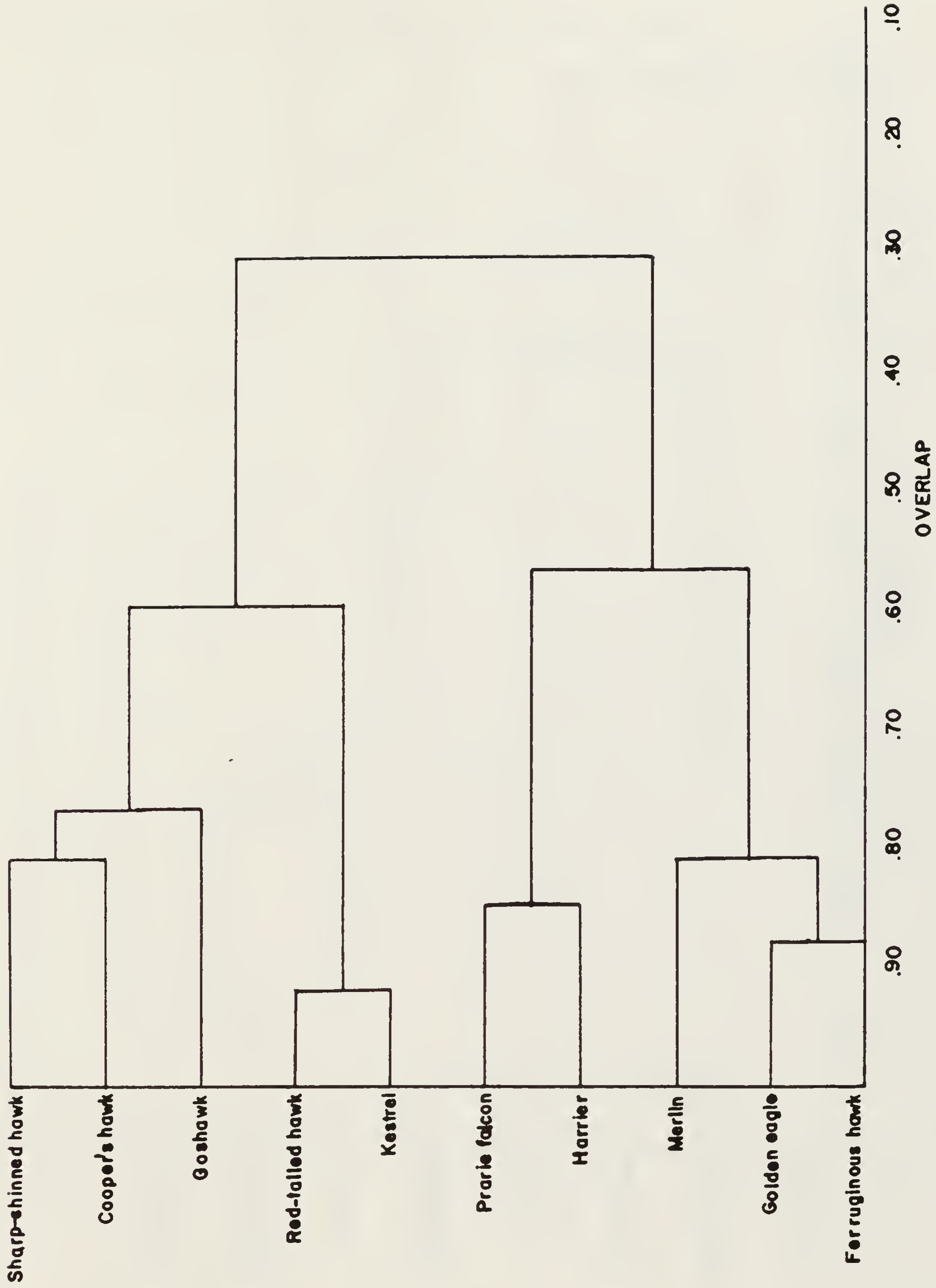


Fig. 5. Dendrogram illustrating distributional relationships between regularly encountered falconiformes in winter. Dendrograms were prepared by subjecting habitat use overlap measurements (Horn 1966) for each species-pair to pair-group cluster analysis (Sokal and Sneath 1963). Species/groups which utilized the same plant communities exhibited high overlap measurements, while species/groups which were rarely sympatric show low overlaps.

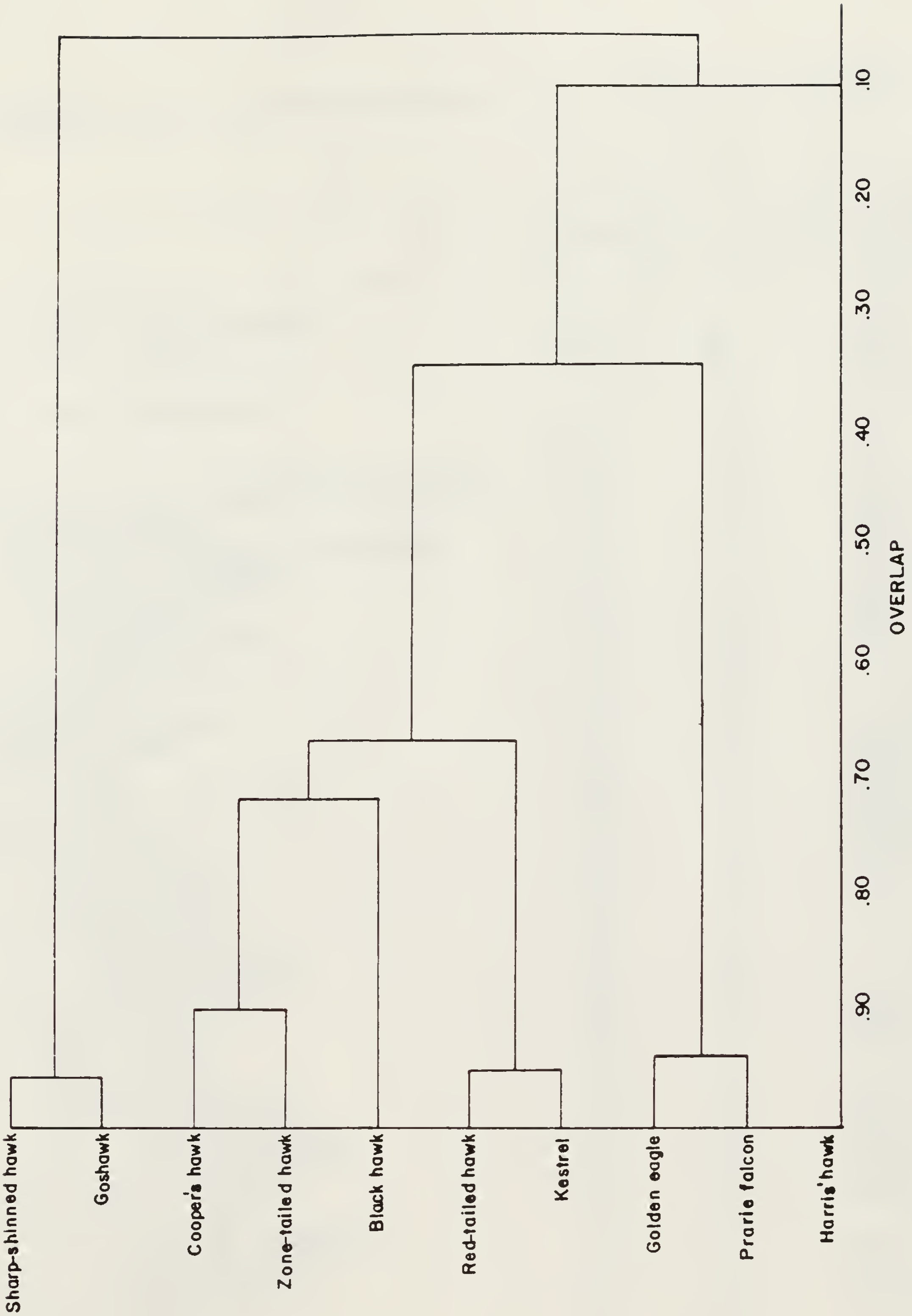


Fig. 6. Dendrogram illustrating distributional relationships between regularly encountered falconiformes in summer. Dendrograms were prepared by subjecting habitat use overlap measurements (Horn 1966) for each species-pair to pair-group cluster analysis (Sokal and Sneath 1963.). Species/groups which utilized the same plant communities exhibited high overlap measurements, while species/groups which were rarely sympatric show low overlaps.

APPENDIX I. - Scientific names of prey species and weights used to determine biomass of falconiform prey in Table 14.

Species	$\bar{X}$ weight (g)	n	Source of Material
Black-tailed jackrabbit (*Lepus californicus*)			
adult[a]	1400	12	Local
juvenile[a]	700	10	"
Unid. Cottontail rabbit (*Sylvilagus spp.*)			
adult[a]	650	16	"
juvenile[a]	300	5	"
Harris' Antelope Ground Squirrel (*Ammospermophilus harrisii*)	105	6	"
Cliff chipmunk (*Eutamias dorsalis*)	68	2	Univ of AZ collect.
Round-tailed ground squirrel (*Spermophilus treticaudus*)	115	3	Local
Rock squirrel (*Spermophilus variegatus*) [a]	260	4	"
Abert's Squirrel (*Sciurus aberti*)	285	2	Univ of AZ collect.
Botta's Pocket Gopher (*Thomomys bottae*)	185	3	Local
Unid. kangaroo rat (*Dipodomys* spp.)	50	12	"
Unid. woodrat (*Neotoma* spp.)	150	6	"
Deer mouse (*Peromyscus maniculatus*)	21	3	"
Cotton rat (*Sigmodon hispidus*)	192	2	Univ of AZ collect.
House mouse (*Mus musculus*)	20	4	Local
Muskrat (*Ondatra zibethicus*)-juvenile only	400	2	Univ of AZ collect.
Ringtail (*Bassariscus astutus*)	580	2	Univ of AZ collect.
Unid. bat (Family Vespertilionidae)	12	6	Univ of AZ collect.
Gambel's Quail (*Lophortyx gambelii*)	287	6	Local
Mourning dove (*Zenaida macroura*)	133	8	"
White-winged dove (*Zenaida asiatica*)	143	2	"
Yellow-billed cucco (*Coccyzus americanus*)	121	1	"
Roadrunner (*Geococcyx californianus*)	255	10	"
Common nighthawk (*Chordeiles minor*)	106	3	Univ of AZ collect.
Poorwill (*Phalaenoptilus nuttalii*)	110	2	Local
Common flicker (*Colaptes auratus*)	131	3	"
Gila woodpecker (*Melanerpes uropygialis*)	137	2	"
Ladder-backed woodpecker (*Picoides scalaris*)	51	3	Univ of AZ collect.
Yellow-bellied sapsucker (*Sphyrapicus varius*)	48	2	Univ of AZ collect.
Western kingbird (*Tyrannus verticalis*)	42	3	Univ of AZ collect.
Cassins' Kingbird (*Tyrannus vociferans*)	42	2	Local
Ash-throated flycatcher (*Myiarchus cinerascens*)	55	4	"
Vermillion flycatcher (*Pyrocephalus rubinus*)	18	3	Univ of AZ collect.
Western wood pewee (*Contopus sordidulus*)	13	2	Univ of AZ collect.
Horned lark (*Eremophila alpestris*)	26	6	Local
Scrub jay (*Aphelocoma coerulescens*)	72	4	"
Bendire's Thrasher (*Toxostoma bendirei*)	55	2	"
Mockingbird (*Mimus polyglottos*)	39	3	Univ of AZ collect.
Hermit thrush (*Catharus guttatus*)	25	1	Univ of AZ collect.
Robin (*Turdus migratorius*)	81	3	Local
Cedar waxwing (*Bombycilla cedrorum*)	34	2	Reynolds 1978

APPENDIX I. - Continued.

Species	$\bar{X}$ weight (g)	n	Source of Material
Starling (Sturnus vulgaris)	79	6	Local
Bell's Vireo (Vireo bellii)	11	3	Univ of AZ collect.
Solitary vireo (Vireo solitarius)	11	2	Univ of AZ collect.
Yellow-rumped Warbler (Dendrocia coronata)	10	3	Local
Yellow warbler (Dendrocia petechia)	10	2	Univ of AZ collect.
Townsend's Warbler (Dendrocia townsendi)	9	3	UNiv of AZ collect.
Northern oriole (Icterus galbula)	38	2	Local
Unid. oriole (Icterus spp.)	38	-	-
Great-tailed grackle (Quiscalus mexicanus)	145	2	Local
Brown-headed cowbird (Molothrus ater)	40	3	Univ of AZ collect.
Summer tanager (Piranga rubra)	41	2	Local
Cardinal (Cardinalis cardinalis)	35	3	Univ of AZ collect.
Rufous-sided towhee (Pipilo erythrophthalmus)	39	3	Univ of AZ collect.
Unid towhee (Pipilo spp.)	39	-	-
Black-headed grosbeak (Pheucticus melanocephalus)	42	2	Univ of AZ collect.
House finch (Carpodacus mexicanus)	20	2	Local
Black-throated sparrow (Amphispiza bilineata)	21	4	"
Lark sparrow (Chondestes grammacus)	19	3	Univ of AZ collect.
White-crowned sparrow (Zonotrichia leucophrys)	24	3	Univ of AZ collect.
Unid medium bird	41	-	-
Unid small bird	15	-	-
Yellow mud turtle (Kinosternon flavescens)	31	2	Local
Chuckwalla (Sauromalus obesus)	122	4	"
Side-blotched lizard (Uta stansburiana)	15	8	"
Long-tailed brush lizard (Urosaurus graciosus)	6	3	"
Tree lizard (Urosaurus ornatus)	6	4	"
Desert spiny lizard (Sceloporus magister)	71	6	"
Zebra-tailed lizard (Callisaurus draconoides)	15	4	"
Collared lizard (Crotaphytus collaris)	55	3	"
Unid whiptail lizard (Cnemidophorus spp.)	25	6	"
Gilbert's Skink (Eumeces gilberti)	30	3	"
Desert horned lizard (Phrynosoma douglassi)	22	4	"
Unid lizard [a]	20	-	-
Coachwhip snake (Masticophis flagellum)[a]	137	3	Local
Western patch-nosed snake (Salvadora hexalepis)[a]	29	5	"
Gopher snake (Pituophis melanoleucus)[a]	298	3	"
California Kingsnake (Lampropeltis getulus)[a]	55	6	"
Glossy snake (Arizona elegans)[a]	24	4	"
Long-nosed snake (Rhinocheilus lecontei)[a]	90	12	"
Black-necked garter snake (Thamnophis cyrtopsis)[a]	30	48	"
Western ground snake (Sonora semiannulata)[a]	7	5	"
Unid rattlesnake (Crotalus spp.)	110	6	"
Leopard frog (Rana pipiens)[a]	17	115	"

APPENDIX I. - Continued.

Species	$\bar{X}$ weight (g)	n	Source of Material
Canyon tree frog (*Hyla arenicolor*)	10	6	Local
Roundtail chub (*Gila robusta*)[a]	55	19	"
Gila Sucker (*Catostomus insignis*)[a]	50	36	"
Gila Mountain Sucker (*Pantosteus clarki*)[a]	60	28	"
Unid sucker	55	-	-
Cicada (*Diceroprocta apache*)	0.6	6	Local
Hornworm (*Sphingidae*)	0.8	2	"
Centipede (*Scolopendra* spp.)	1.4	2	"
Scorpion (*Centroidies* spp.)	1	6	"

[a] Weights presented are not necessarily those used in biomass computations in Table 15. Where possible weight of a comparable-sized specimen was used.

APPENDIX II. Photographs of Plant Communities

Montane conifer forest, ponderosa pine-Gambel Oak association. Bradshaw Mountains, Yavapai County, Arizona (not on study area). ca. 2340 m elevation. Falconiformes observed in this plant community in summer (from highest to lowest relative abundance) were the Cooper's Hawk, goshawk, turkey vulture, American Kestrel, red-tailed hawk, zone-tailed hawk and sharp-shinned hawk. Studies were not conducted in winter.

APPENDIX II. Continued.

Pinyon-juniper woodland, Walnut Grove, Yavapai County, Arizona. ca. 1340 m elevation. Falconiformes observed in this plant community (from highest to lowest relative abundance) were: 1) winter-red-tailed hawk, Cooper's Hawk, American Kestrel and sharp-shinned hawk; and 2) summer-Cooper's Hawk, American Kestrel, red-tailed hawk and turkey vulture.

Interior chaparral plant community, shrub live oak association. Weaver Mountains, Yavapai County, Arizona. ca. 1530 m elevation. Falconiformes observed in this plant community (from highest to lowest relative abundance) were: 1) winter-American Kestrel, red-tailed hawk, Cooper's Hawk, golden eagle, sharp-shinned hawk, ferruginous hawk, goshawk, prairie falcon and northern harrier; and 2) summer-American Kestrel, turkey vulture, Cooper's Hawk, red-tailed hawk, prairie falcon, golden eagle and zone-tailed hawk.

Desert grassland plant community, tobosa-mixed scrub association. Two km west Kirkland Junction, Yavapai County, Arizona. ca. 1300 m elevation. Falconiformes observed in this plant community (from highest to lowest relative abundance) were: 1) winter-American Kestrel, red-tailed hawk, prairie falcon, golden eagle, northern harrier, merlin, ferruginous hawk and Cooper's Hawk; and 2) summer-American Kestrel, red-tailed hawk, turkey vulture, prairie falcon, zone-tailed hawk, golden eagle and ferruginous hawk.

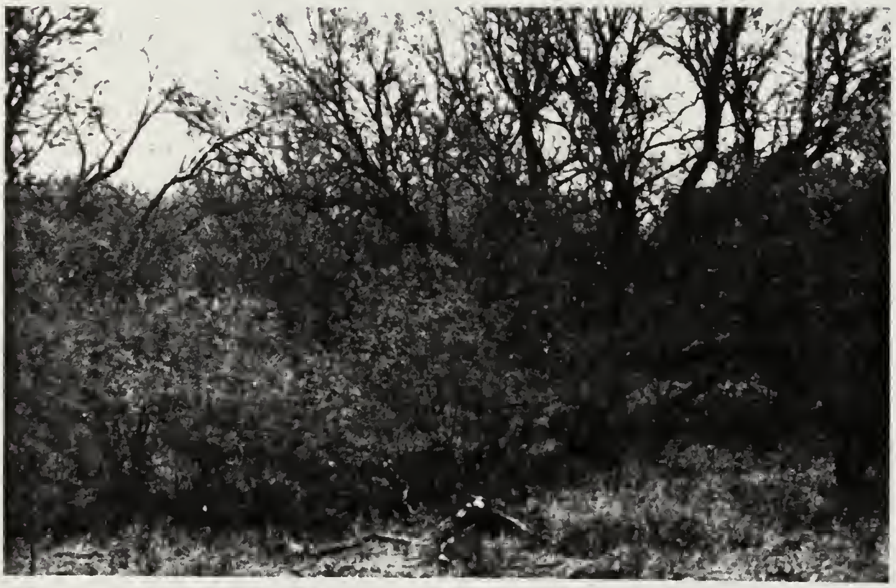
Joshuatree-creosotebush plant community, vicinity Tres Alamos Spring, Yavapai County, Arizona. ca. 800 m elevation. Falconiformes observed in this plant community (from highest to lowest relative abundance) were: 1) winter-American Kestrel, red-tailed hawk, prairie falcon, golden eagle, Cooper's Hawk and northern harrier; and 2) summer-American Kestrel, turkey vulture, red-tailed hawk, prairie falcon, and golden eagle.

Paloverde-saguaro plant community, Vulture Peak vicinity, Maricopa County, Arizona. ca. 550 m elevation. Falconiformes observed in this plant community (from highest to lowest relative abundance) were: 1) winter-American Kestrel, red-tailed hawk, northern harrier, Cooper's Hawk, sharp-shinned hawk, prairie falcon, golden eagle and Harris' Hawk; and 2) summer-American Kestrel, red-tailed hawk, turkey vulture, prairie falcon, Cooper's Hawk, zone-tailed hawk and Harris' Hawk.

Creosotebush-bursage plant community, Hassayampa Plain, Maricopa County, Arizona. ca. 460 m elevation. Falconiformes observed in this plant community (from highest to lowest relative abundance) were: 1) winter-American Kestrel, red-tailed hawk, prairie falcon, northern harrier, Cooper's Hawk, golden eagle and sharp-shinned hawk; and 2) summer-American Kestrel, turkey vulture, red-tailed hawk, prairie falcon and golden eagle.

Mixed broadleaf riparian forest plant community, ash-walnut association, Arrastre Creek, Yavapai County, Arizona. ca. 1360 m elevation. Falconiformes observed in this plant community (from highest to lowest relative abundance) were: 1) winter-Cooper's Hawk, American Kestrel, sharp-shinned hawk, red-tailed hawk and bald eagle; and 2) summer-Cooper's Hawk, American Kestrel, turkey vulture, zone-tailed hawk, red-tailed hawk and common black hawk.

Cottonwood-willow riparian forest plant community, Hassayampa River, Yavapai County, Arizona, ca. 1050 m elevation. Falconiformes observed in this plant community (from highest to lowest relative abundance) were: 1) winter-American Kestrel, Cooper's Hawk, red-tailed hawk, Harris' Hawk and bald eagle, and 2) summer-American Kestrel, Cooper's Hawk, red-tailed hawk, turkey vulture, common black hawk, zone-tailed hawk, Harris' Hawk and Mississippi Kite.



Mesquite-saltcedar woodland plant community, Kirkland Creek, Yavapai County, Arizona. ca. 760 m elevation. Falconiformes observed in this plant community (from highest to lowest relative abundance) were: 1) winter-Cooper's Hawk, red-tailed hawk, sharp-shinned hawk, American Kestrel and Harris' Hawk; and 2) summer-Cooper's Hawk, red-tailed hawk, American Kestrel and Harris' Hawk.

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